GeoEvent Server:
Internet of Things (IoT)

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Real-Time GIS

The Internet of Things (IoT)

Agenda

1. The Internet of Things (IoT)
2. IoT Trends and Landscape
3. IoT Applications and Markets
4. Real-Time GIS and IoT
5. Using GeoEvent with IoT
6. Collecting and storing IoT data

The Internet of Things

The Internet of Things (IoT)

Everything Connected

- **Network of physical objects embedded with electronics, software, sensors, and network connectivity**
  - **Enables the objects to collect and exchange data**
  - **Allows objects to be sensed and controlled remotely**

The Internet of Things (IoT)

International Adoptions

- **List of countries by IoT devices online per 100 inhabitants (OECD 2015)**
  - **Korea 38 devices/100 people**
  - **US 25 devices/100 people**
  - **China 6 devices/100 people**
  - **India 1 device/100 people**

OECD
BETTER POLICIES FOR BETTER LIVES

Rank	Country	Devices online	Relative size
1	Korea	37.9	
2	Denmark	32.7	
3	Switzerland	29.0	
4	United States	24.9	
5	Netherlands	24.7	
6	Germany	22.4	
7	Sweden	21.9	
8	Spain	19.9	
9	France	17.6	
10	Portugal	16.2	
11	Belgium	15.6	
12	United Kingdom	13.0	
13	Canada	11.6	
14	Italy	10.2	
15	Brazil	9.2	
16	Japan	8.2	
17	Australia	7.9	
18	Mexico	6.8	
19	Poland	6.3	
20	China	6.2	
21	Colombia	6.1	
22	Russia	4.9	
23	Turkey	2.3	
24	India	0.6	

The Internet of Things (IoT)

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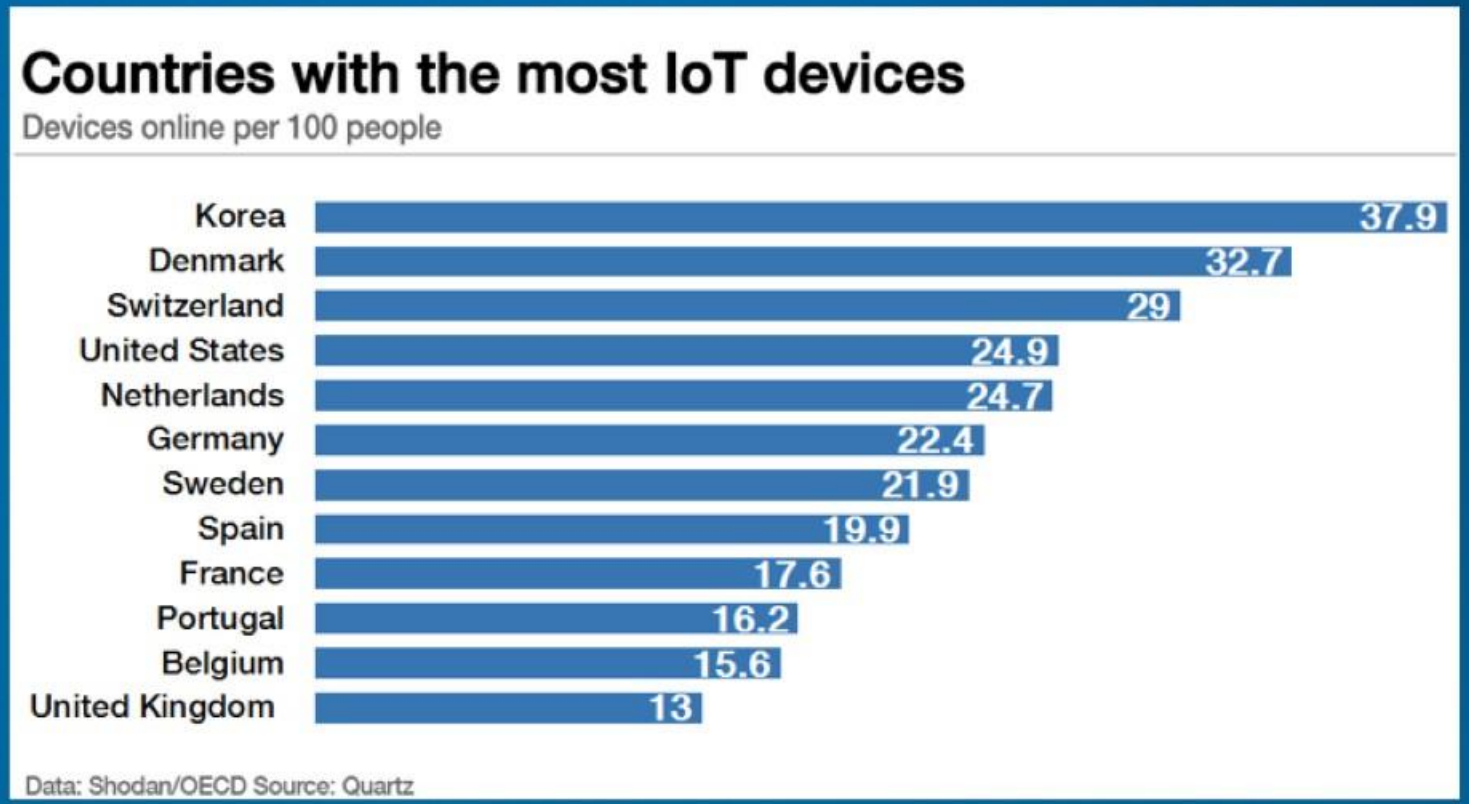


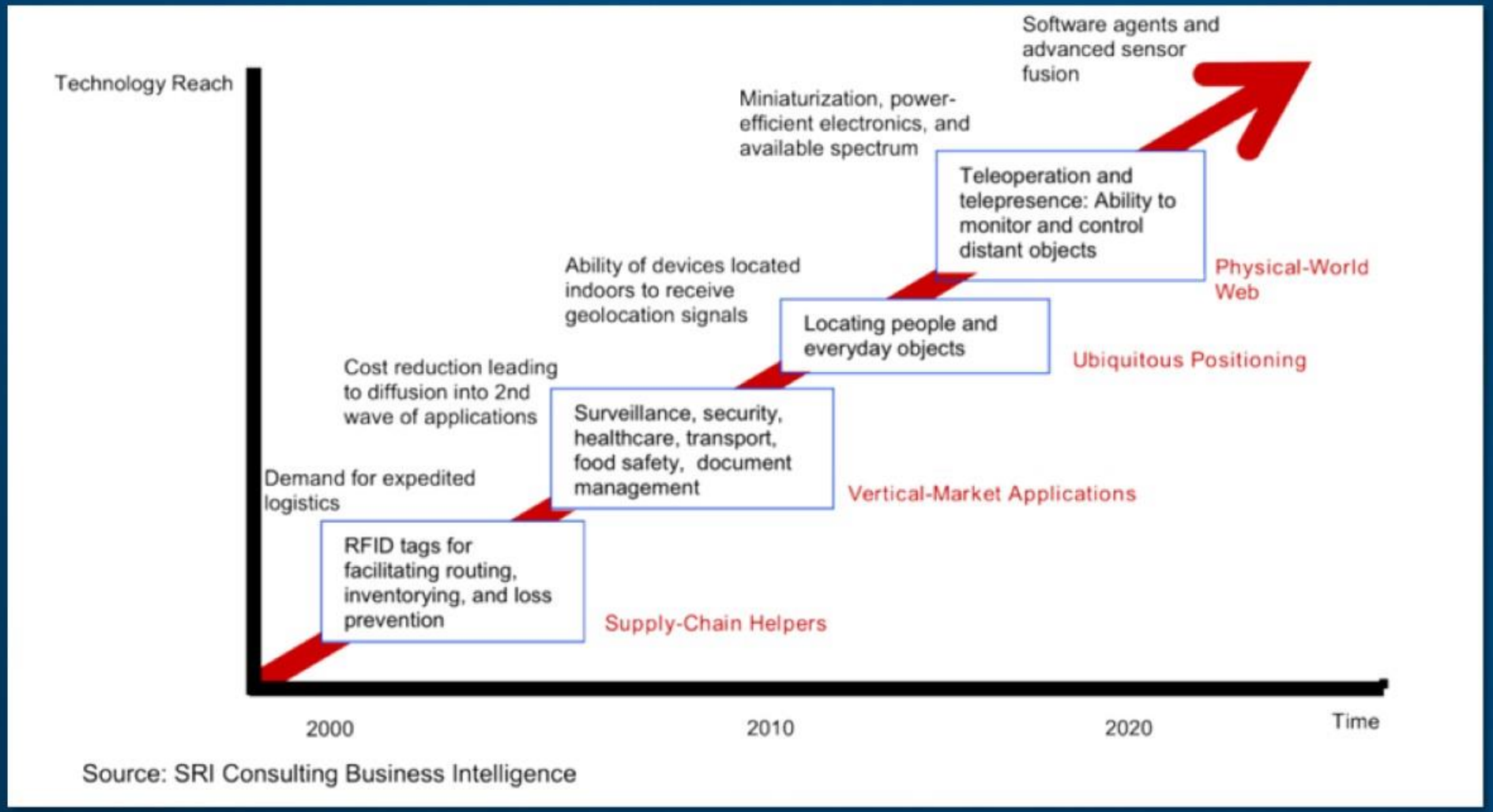
OECD
BETTER POLICIES FOR BETTER LIVES

The Internet of Things

Technology Trends and Landscape

The Internet of Things (IoT)

Technology Trends

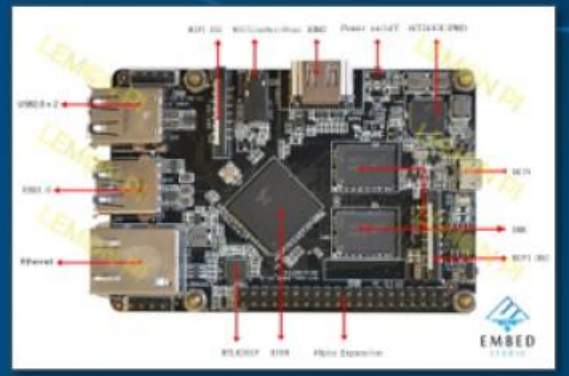


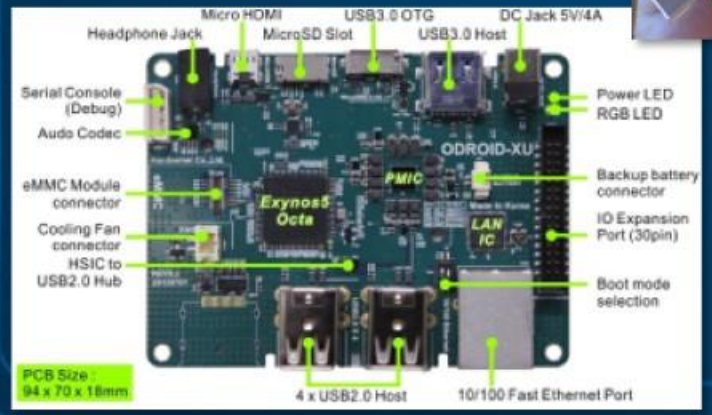
Verizon: The worldwide spend on IoT devices will reach $1.3 trillion with more than 25.6 billion endpoints by 2019

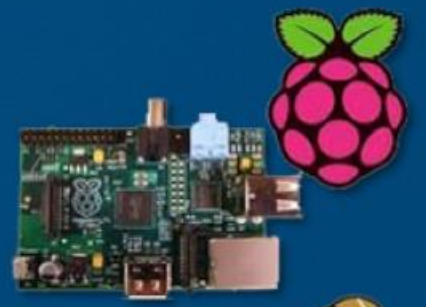
The Internet of Things (IoT)

Enabling computing technologies

- **Credit card sized computers**
- **Computer on stick**
- **System on chip (SoC)**



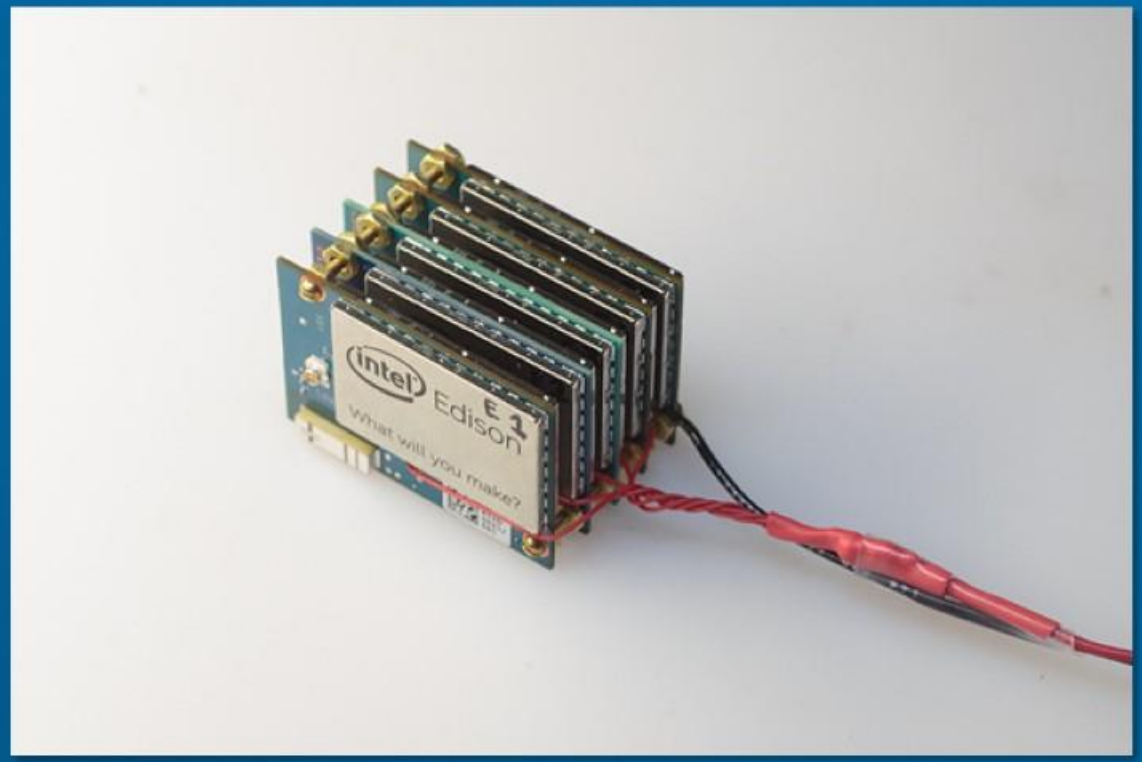




The Internet of Things (IoT)

Enabling computing technologies

A matchbox sized cluster



http://lcamtuf.coredump.cx/edison_fuzz/

The Internet of Things (IoT)

Enabling computing technologies

- RFID and NFC
- Optical tags – QR code
- Bluetooth Low Energy (BLE)
- Low energy wireless IP networks
- ZigBee
- Z-Wave
- LTE-Advanced
- WiFi-Direct
- WiTricity

The Internet of Things (IoT)

IoT Landscape – IoT Platform Providers

- Microsoft Azure IoT Hub

- Amazon AWS IoT

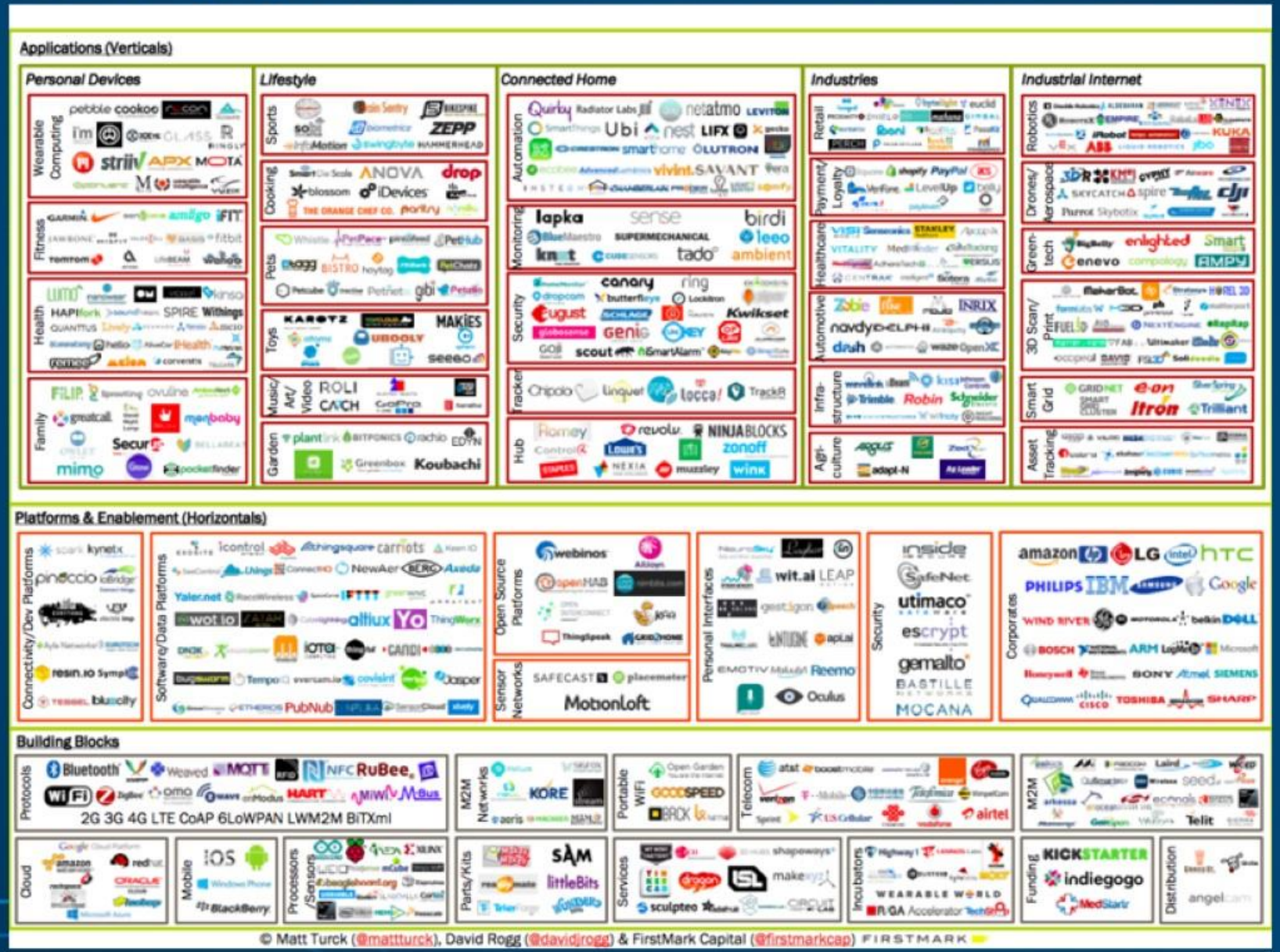
- AT&T IoT
- IBM Watson Internet of Things

- Verizon IoT

- Cisco

The Internet of Things (IoT)

IoT Landscape

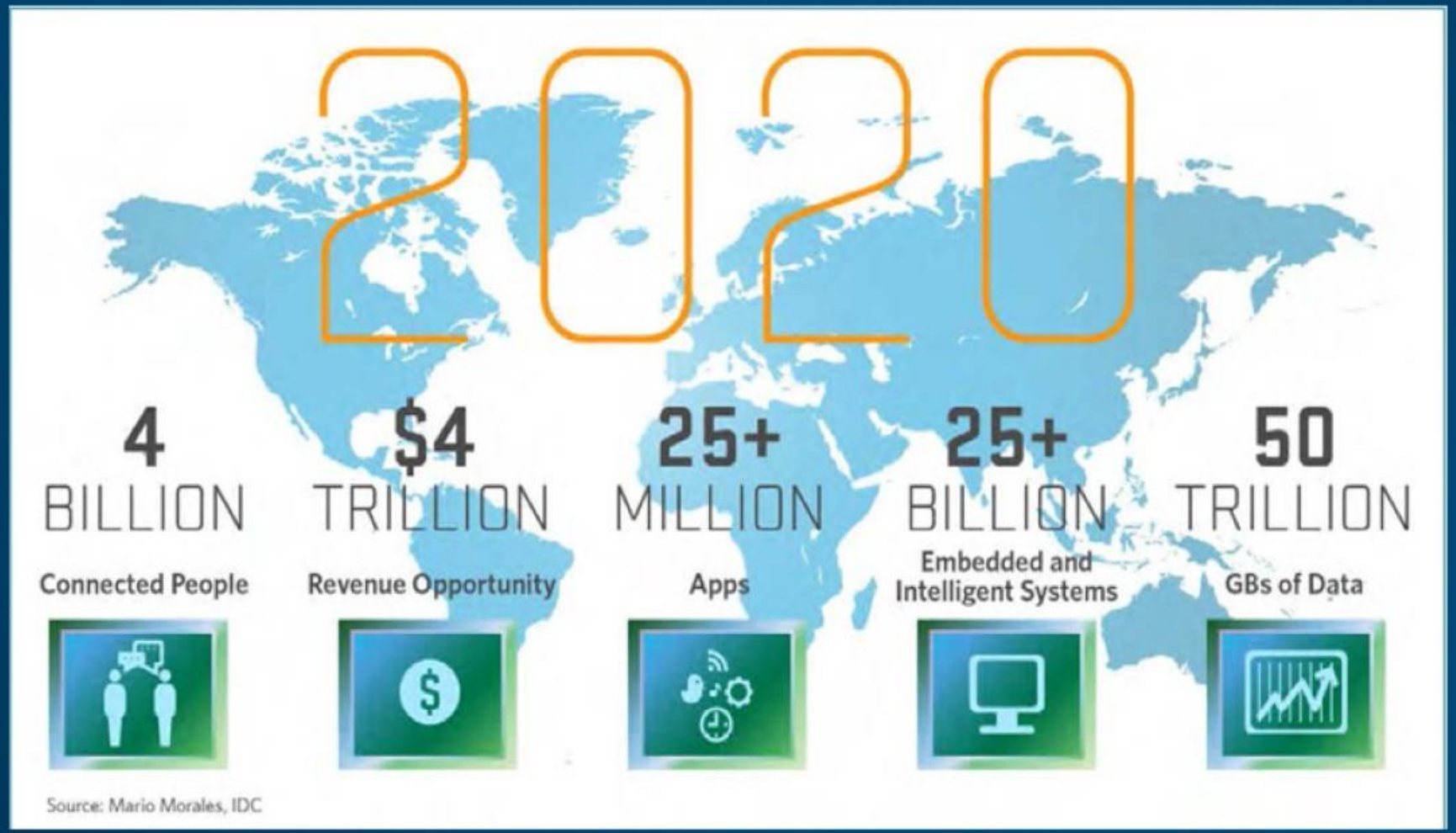


The Internet of Things

Applications and Markets

The Internet of Things (IoT)

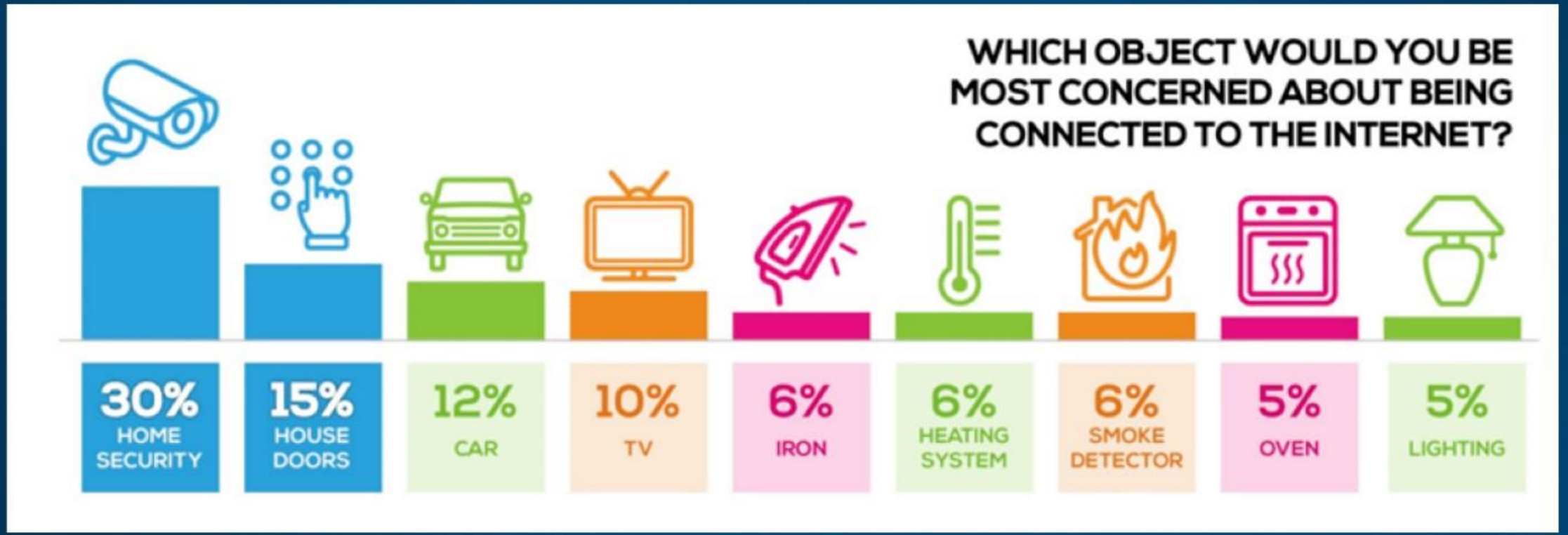
2020 Forecasts



Salesforce: There is expected to be 75 billion connected devices by 2020

The Internet of Things (IoT)

Which objects should be connected

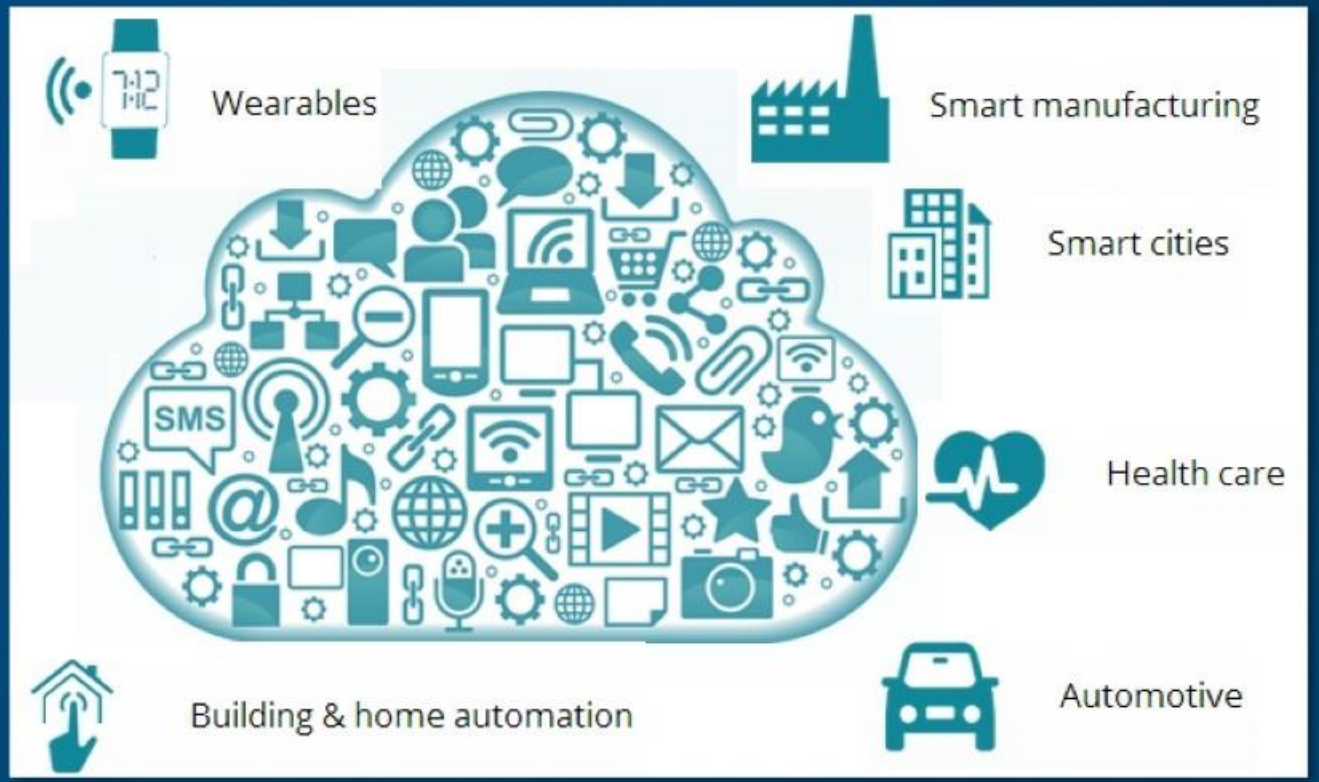


Source: Mobile Ecosystem Forum

The Internet of Things (IoT)

IoT Applications/Markets

- Smart cities
- Environmental monitoring
- Infrastructure management
- Energy management
- Retail – inventory management
- Medical and healthcare
- Building and home automation
- Transportation - connected car
- Wearable
- Smart agriculture



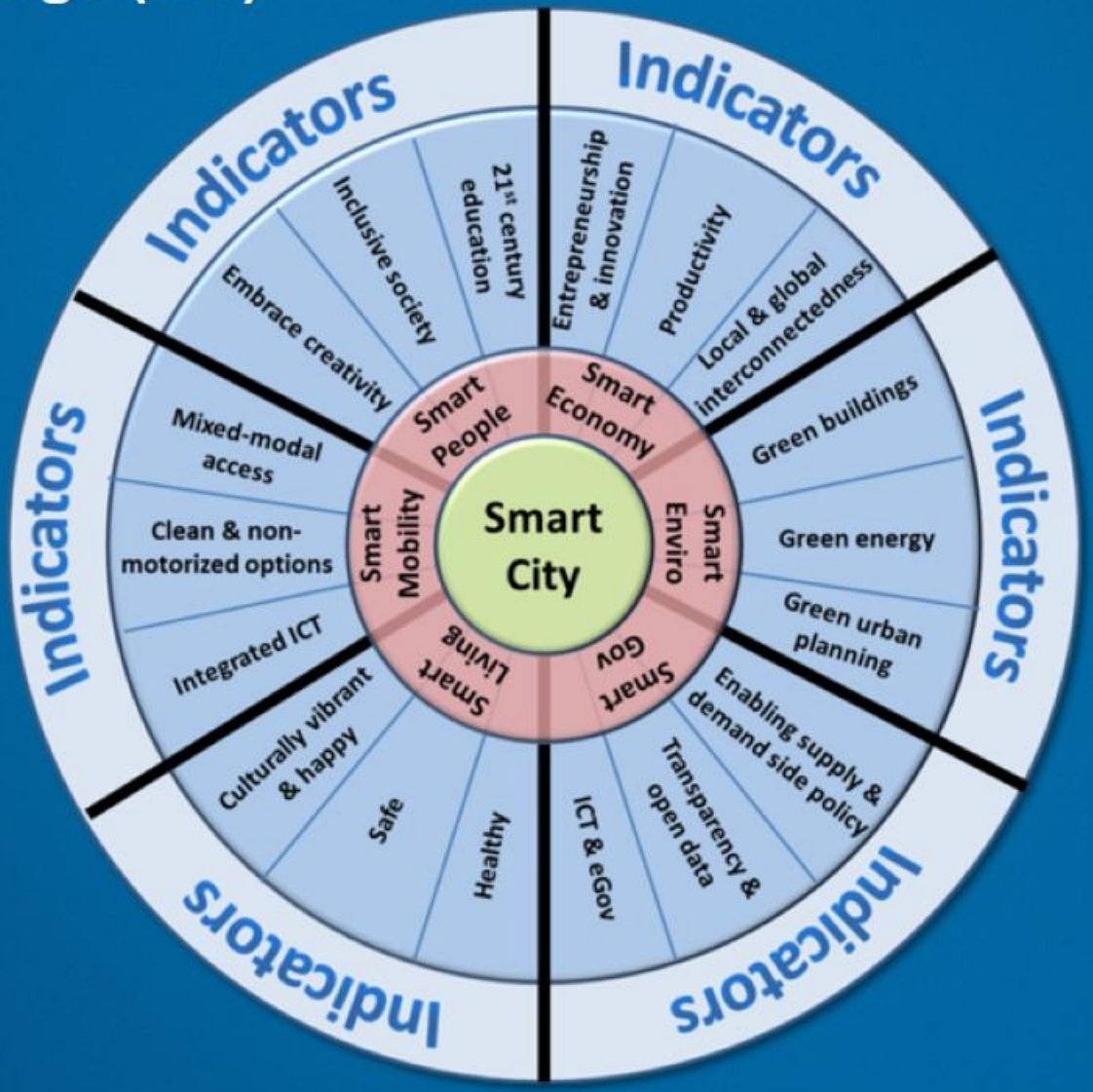
http://itersnews.com/

The Internet of Things (IoT)

Smart Cities

The Internet of Things (IoT)

Smart City Indicators



http://www.fastcoexist.com/1680538/what-exactly-is-a-smart-city

Smart City KPI

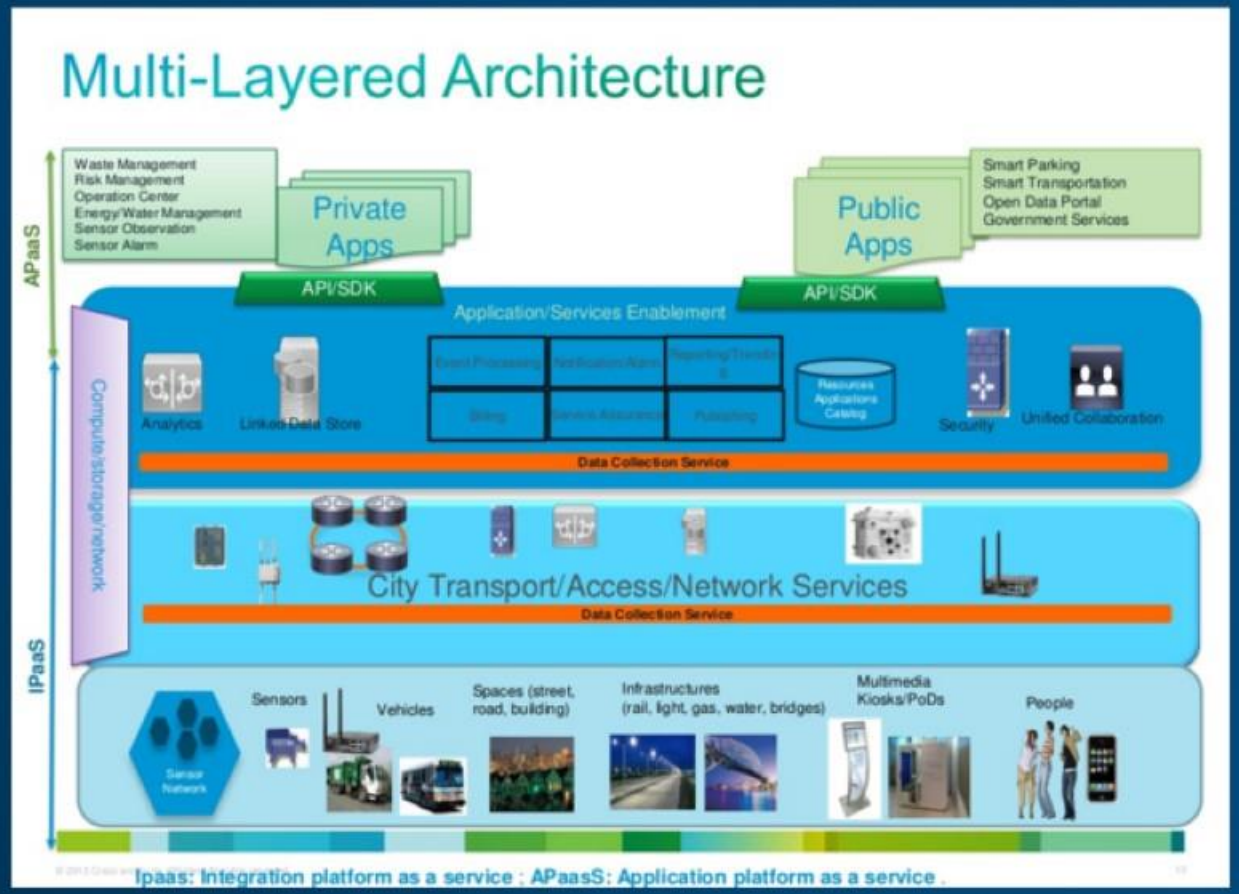
Information and Communication Technology (ICT) related indicator

- Network and access
- Services and information platforms
- Information security and privacy
- Electromagnetic field

Source: FG-SSC “Overview of key performance indicators in smart sustainable cities”

Smart City Operating System

Multi-Layered Architecture

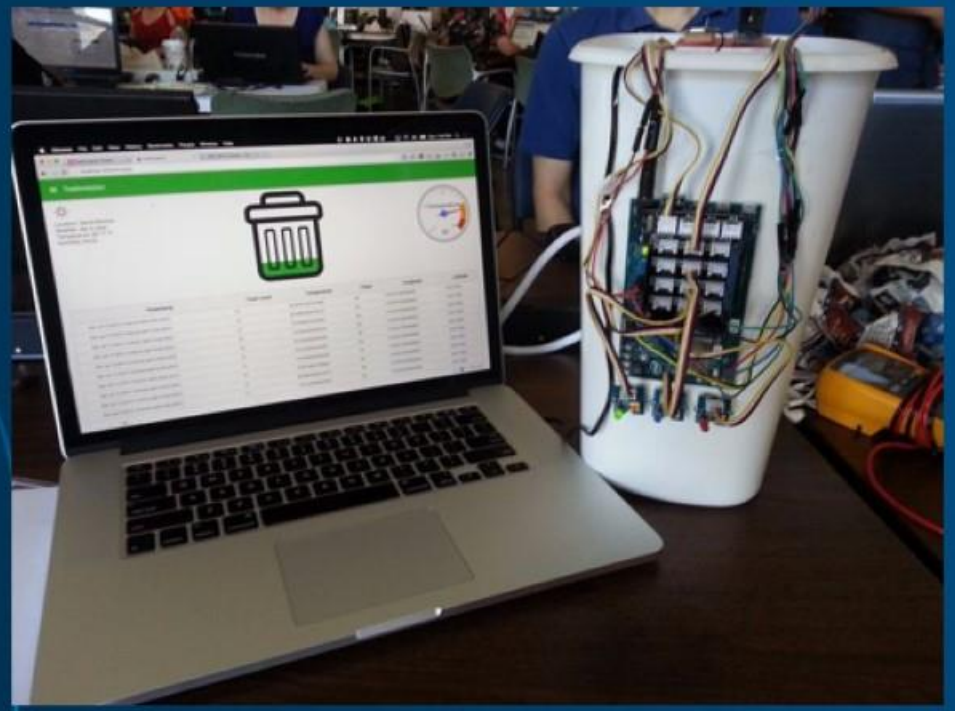


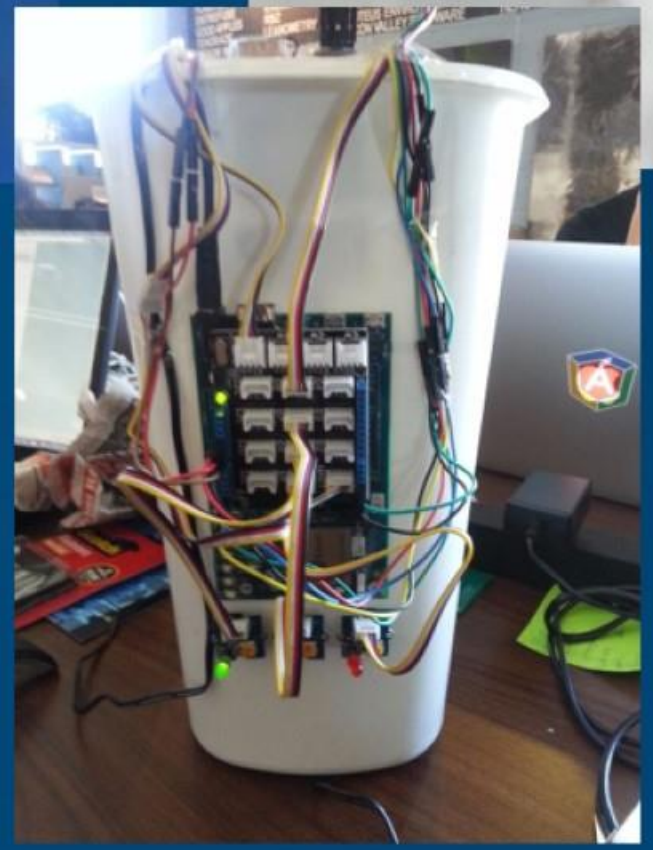
- **Smart Parking**
- **Smart Lighting**
- **Waste Management**
- **Environment Monitoring**
- **etc**

Source: Prakash Kumar, Cisco, “Smart Cities, Global Experiences and Lessons for India”

Smart Trashcan

IoT 36-Hour Hackathon Project





1 x Intel IoT Edition board with Grove Starter kit and shield
1 x HC-SR04 ultrasonic sensor
1 x SIM28 GPS sensor
1 x Grove kit temperature sensor
1 x ADXL335 Tilt Angle Module
1 x Grove kit Speaker
1 x Red LED
1 x Green LED
1 x Blue LED

http://www.instructables.com/id/Smart-Trashcan-Module/

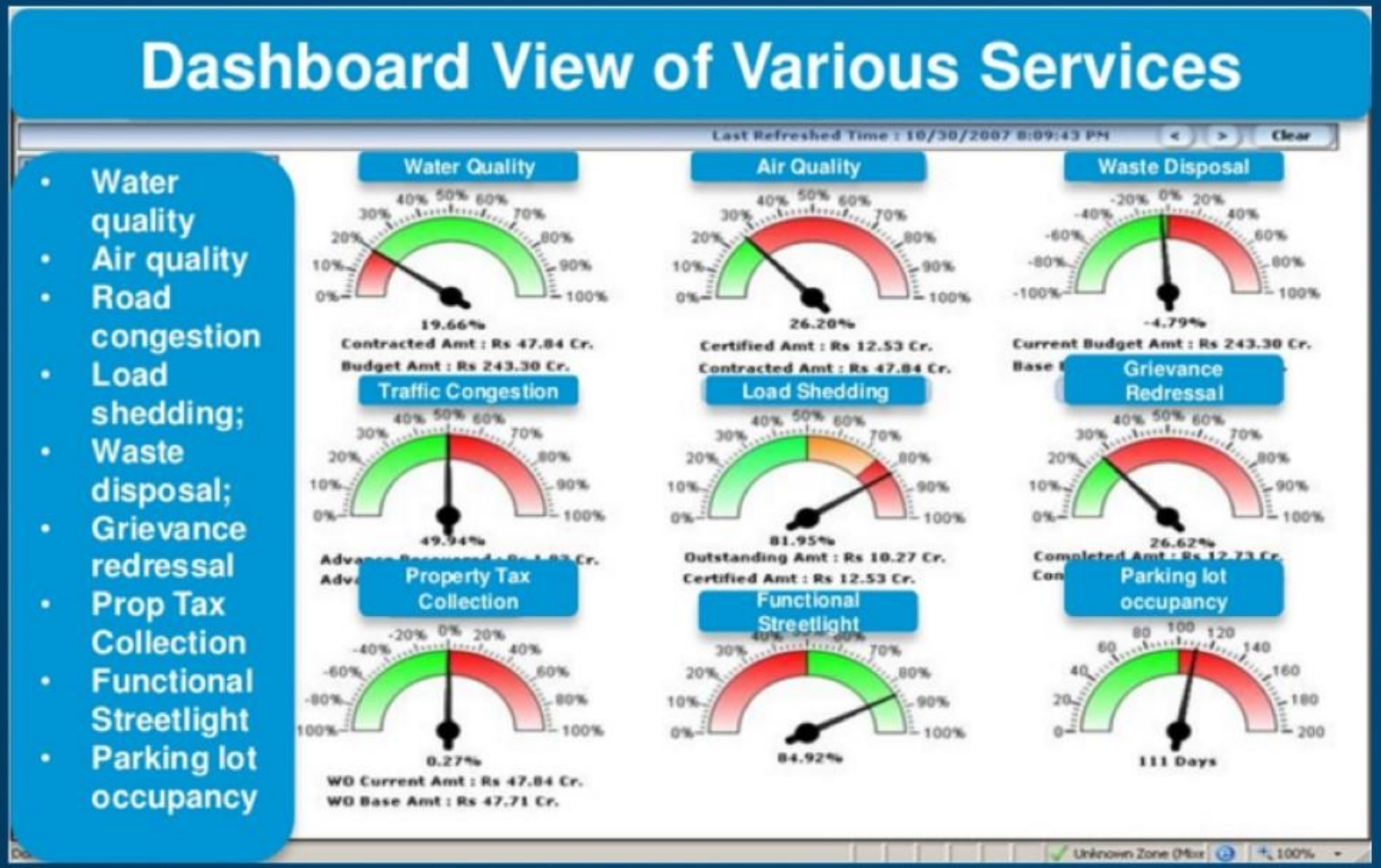
Smart Trash Cans

BigBelly - SmartBelly

- **Solar powered with battery**
- **Trash compactor**
- **Used in Boston, Philadelphia, Chicago**

Smart City Dashboard

City Dashboard – Cisco for Hyderabad

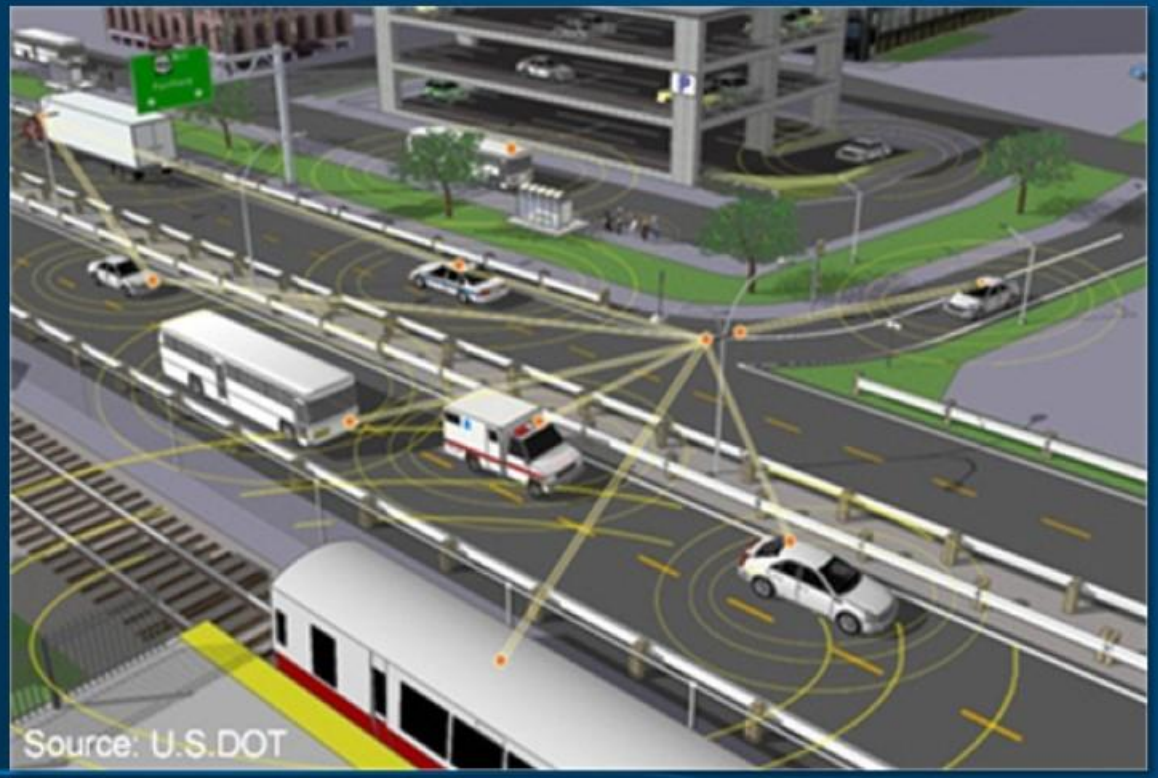


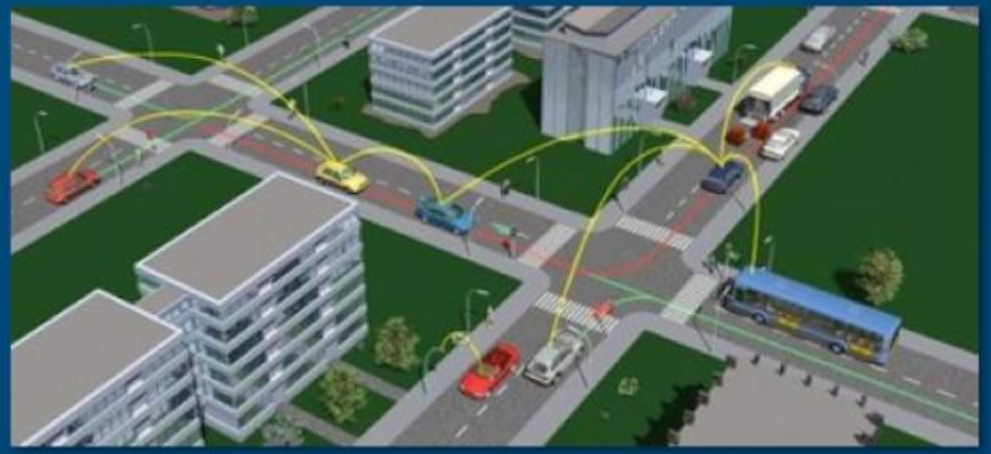
Source: Prakash Kumar, Cisco, “Smart Cities, Global Experiences and Lessons for India”

The Internet of Things (IoT)

Connected Car / Smart Transit

- **Connected Cars**
  - **AT&T Drive Studio: "Smart phone on four wheels"**
  - **Nissan, Tesla, GM, Ford, BMW, Audi**





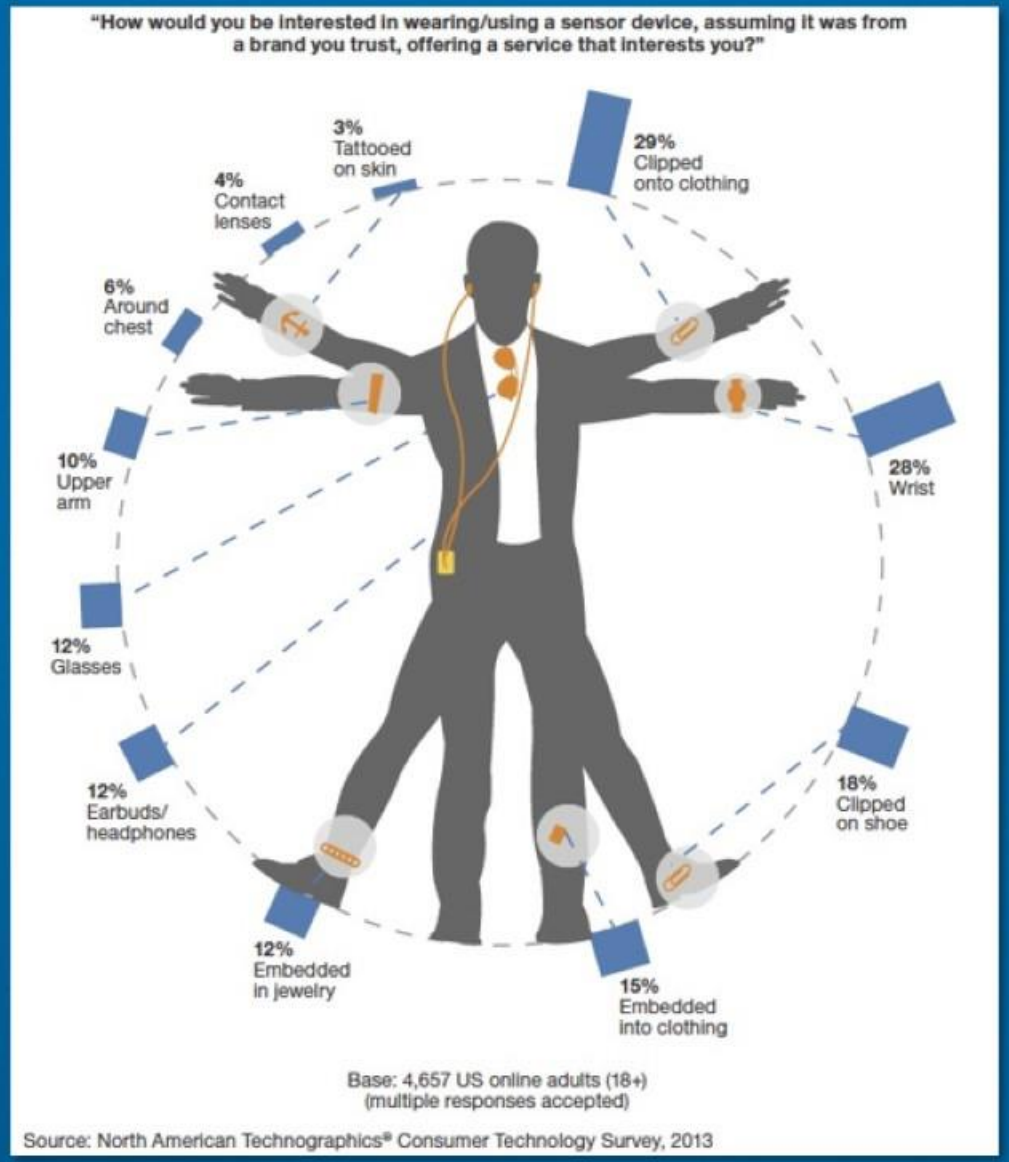
The Internet of Things (IoT)

Connected Car Landscape

Image courtesy of Venture Scanner (venturescanner.com)

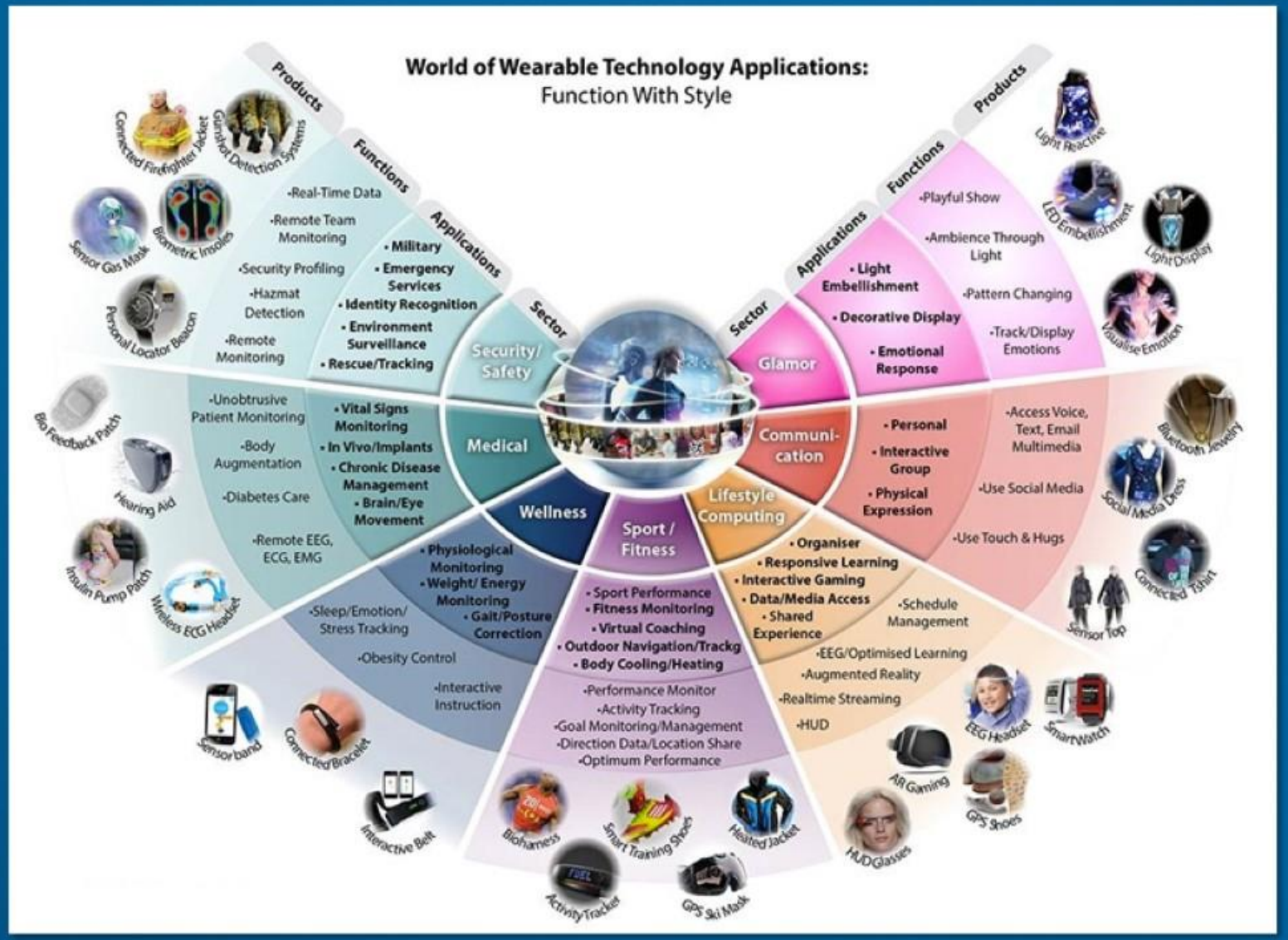
The Internet of Things (IoT)

Wearables



The Internet of Things (IoT)

Wearables

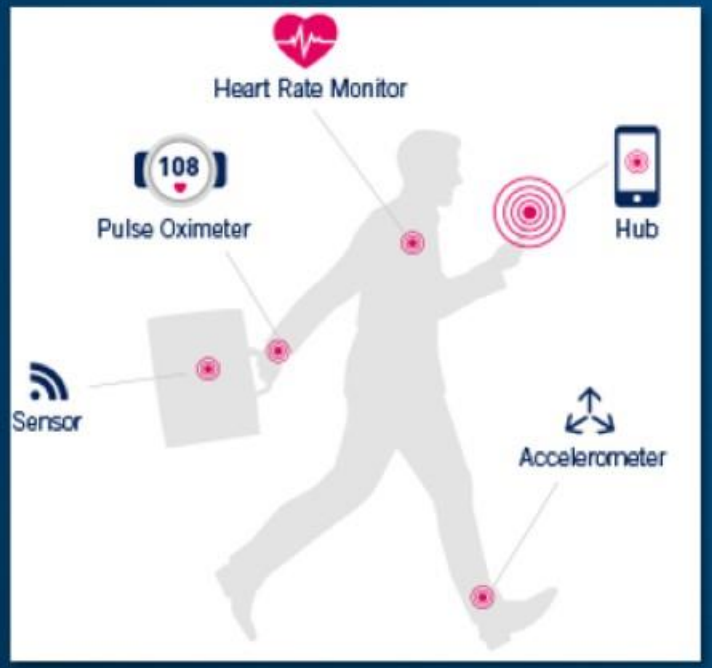


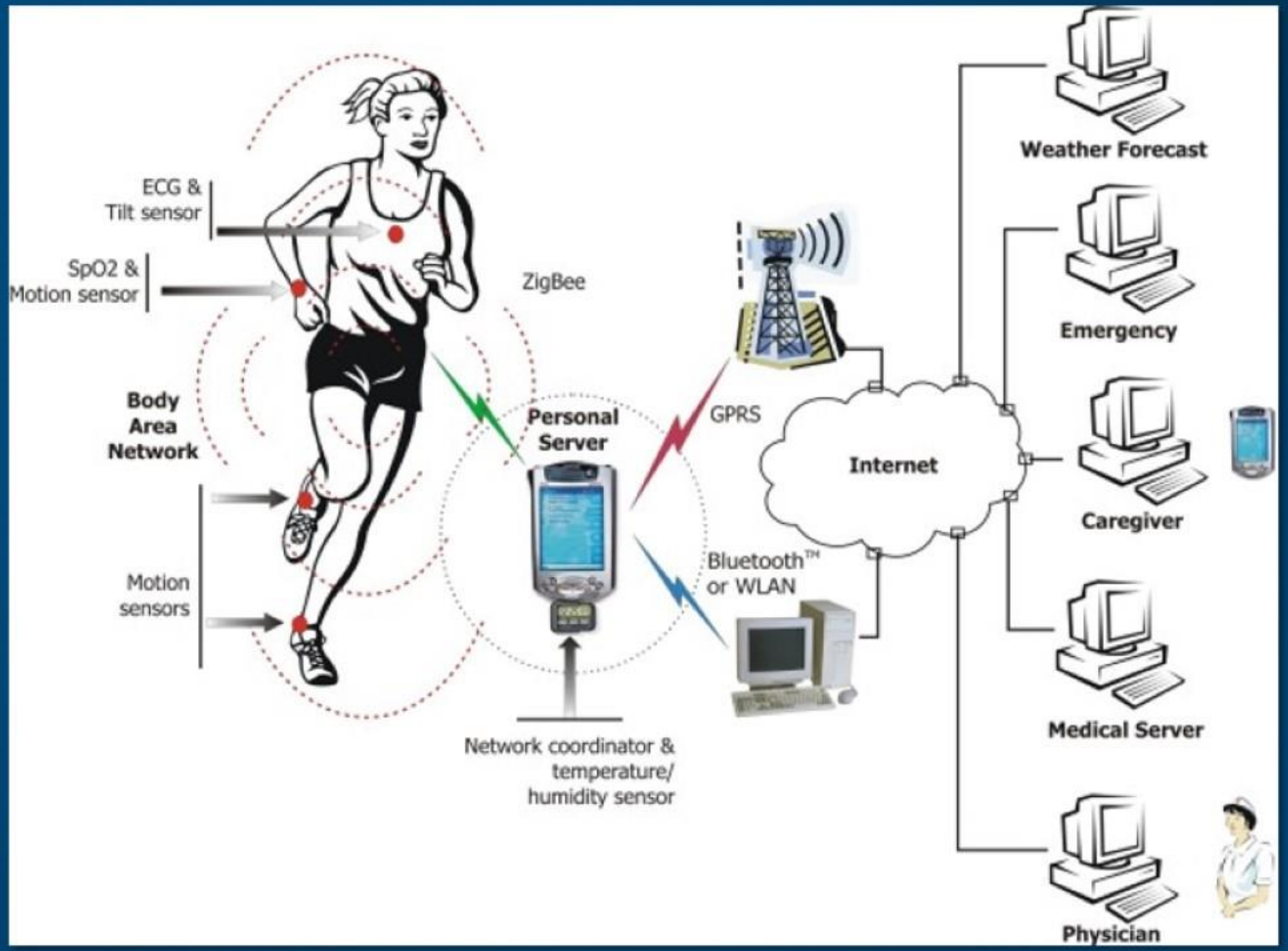
The Internet of Things (IoT)

Wearables

The Internet of Things (IoT)

Wearables





Demo

Smartphone Sensors

Sensors on Smartphone

Embedded sensors

- Three broad categories of sensors
  - Motion sensors
  - Environmental sensors
  - Position sensors

Sensors on Smartphone

Embedded sensors

Sensor	Type	Function	Applications
Accelerometer	Hardware	x, y, z acceleration force in m/s^2	motion, shake, tilt
Ambient Temperature	Hardware	Room temperature in *Celsius*	air temperatures
Gravity	Software + Hardware	x, y, z gravity in m/s^2	motion, shake, tilt
Gyroscope	Hardware	x, y, z rotation in *rad/s*	spin, turn
Light	Hardware	Light level in *lux*	screen brightness
Linear Acceleration	Software + Hardware	x, y, z acceleration in m/s^2 (no gravity)	acceleration along an axis
Magnetic Field	Hardware	x, y, z geomagnetic μT	compass
Orientation	Hardware	x, y, z rotation matrix	device position
Pressure	Hardware	Air pressure *hPa* or *mbar*	air pressure changes
Proximity	Hardware	Screen proximity in *cm*	phone screen position from an object
Relative Humidity	Software + Hardware	Relative humidity in *%*	dew point, humidity
Rotation Vector	Software + Hardware	x, y, z device orientation	motion, rotation
Temperature	Hardware	Device temperature in *Celsius*	Device temperatures

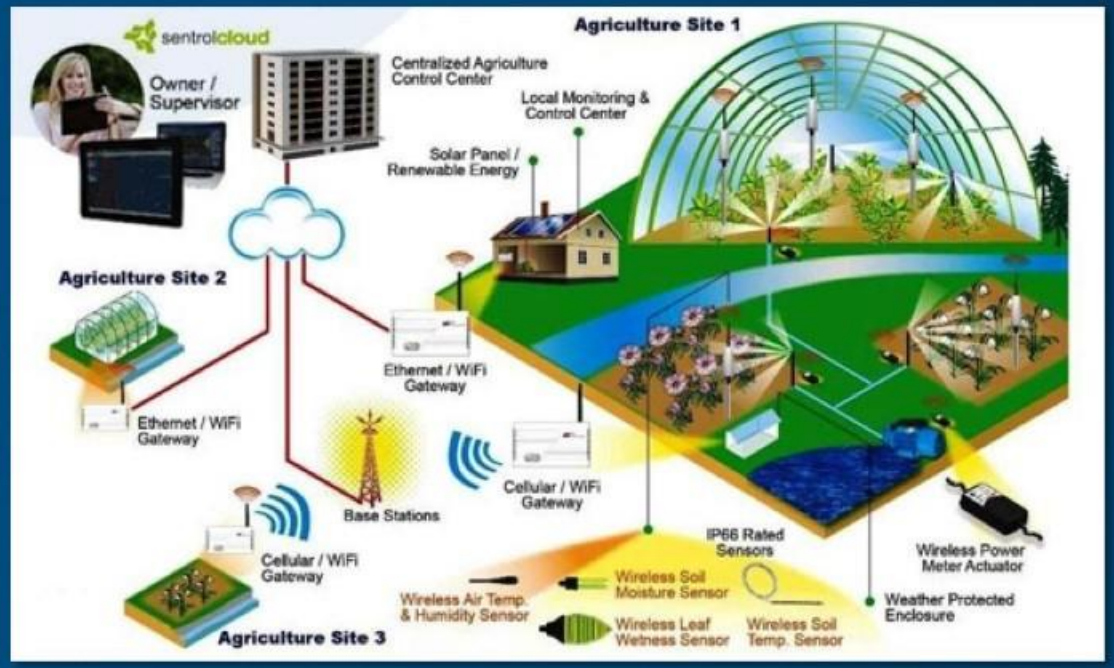
Internet of Things (IoT)

Smartphone sensors demo

The Internet of Things (IoT)

Connected Environment

- **Connected Environment**
  - **Environmental Sensors**
  - **Nature to Machine interface**



Soil Chemistry Sensors

Chemical Sensor

Reports volatile organic compounds

Light Sensor

Reports luminosity

Micro Weather Station

Reports ambient temperature, relative humidity & barometric pressure

Valarm Sensors

Anemometer Sensor

Measures Wind Speed

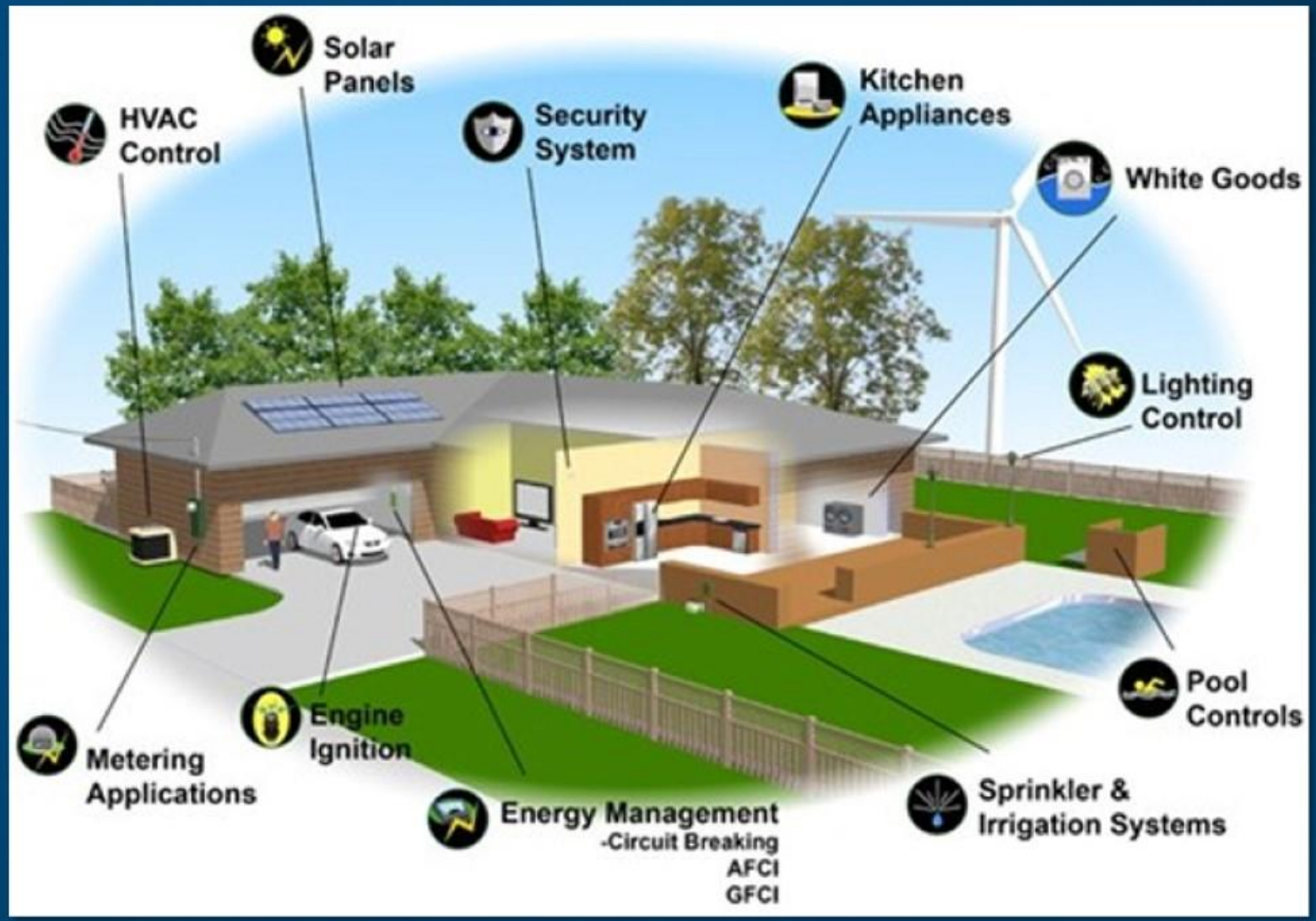
CO2 Air Quality

Reports carbon dioxide

The Internet of Things (IoT)

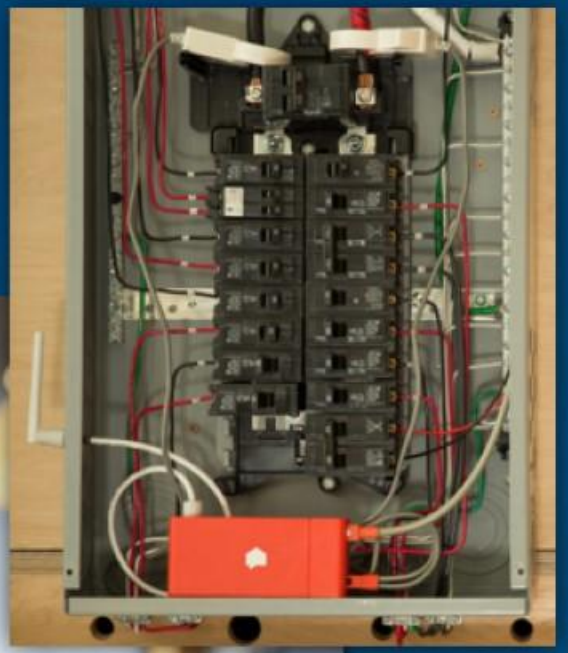
Connected Buildings / Homes

- **Connected Buildings**
  - Smart appliances
  - Monitoring



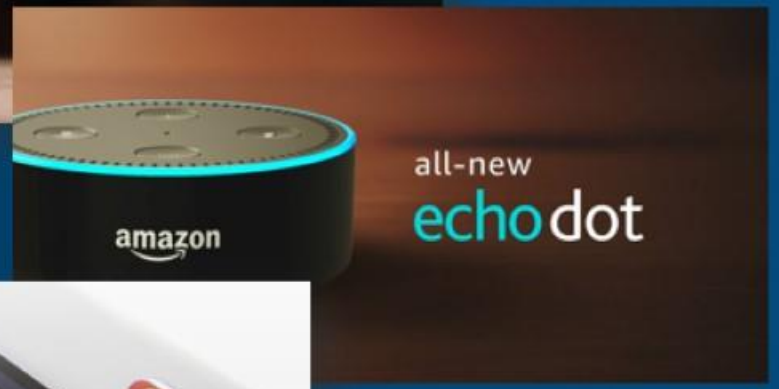
The Internet of Things (IoT)

Connected Buildings / Homes



The Internet of Things (IoT)

Connected Buildings / Homes



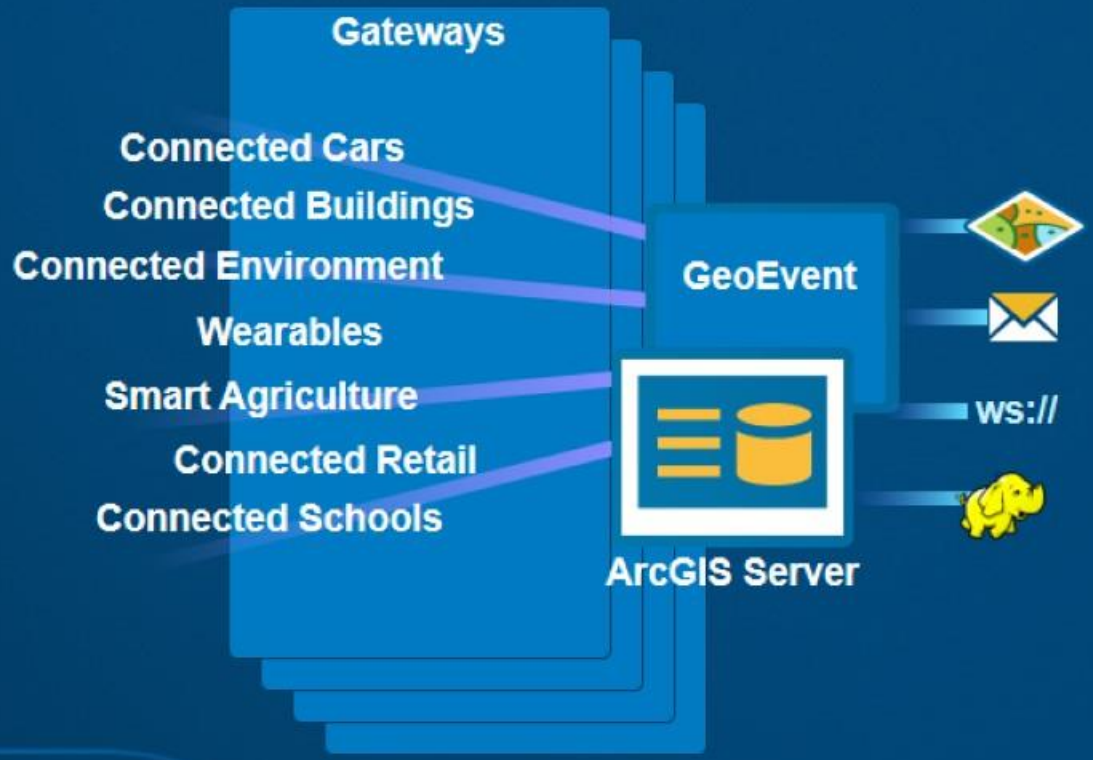
The Internet of Things

Real-Time & Big Data GIS (and IoT)

Real-Time GIS and The Internet of Things

Enable real-time spatial reasoning

- Spatial reasoning is needed amongst the Internet of Things
- Performing continuous analytics closer to the things can improve their ability to sense
- When meaningful patterns are found things can send updates to those who need it



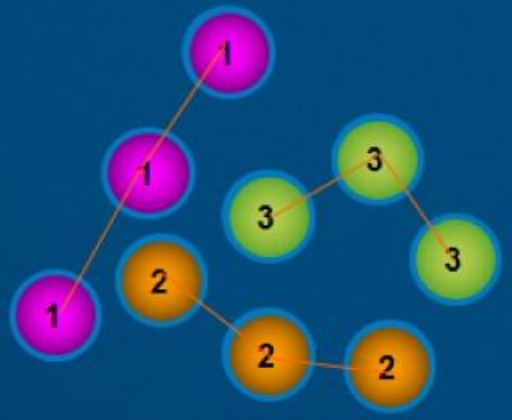
Observation data
defined

- **An observation is a recording of a feature's attribute values and location at a specific moment in time.**
  - **Observations are immutable, they happen and are typically not edited.**
  - **Observations can be replayed over space & time.**
  - **Moving observations are identifiable by a unique attribute, known as a TRACK_ID.**

space & time

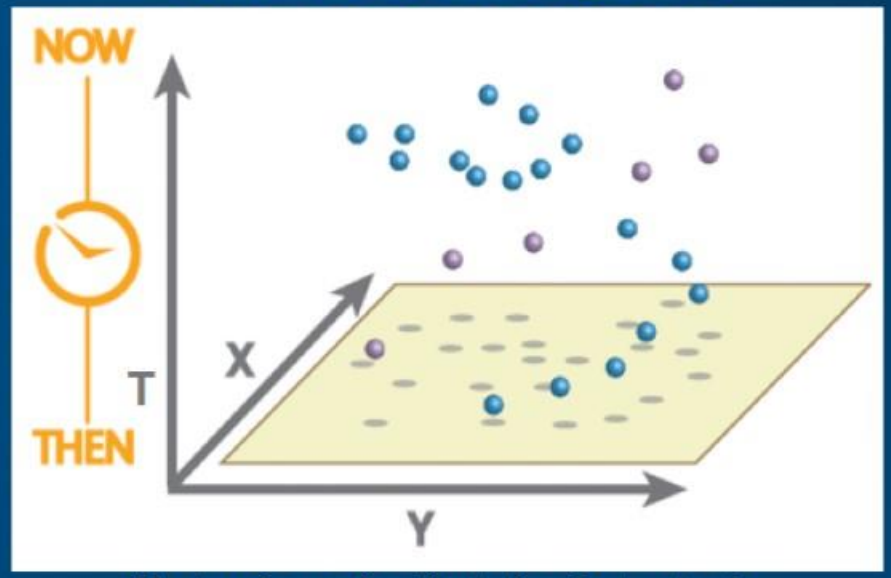
Observations can be shown at a specific time

tracks



Moving observations can be identified by a unique attribute

the tracks of moving observations can be reconstructed



Moving observation illustration for two tracks over space (X, Y) and time (T)

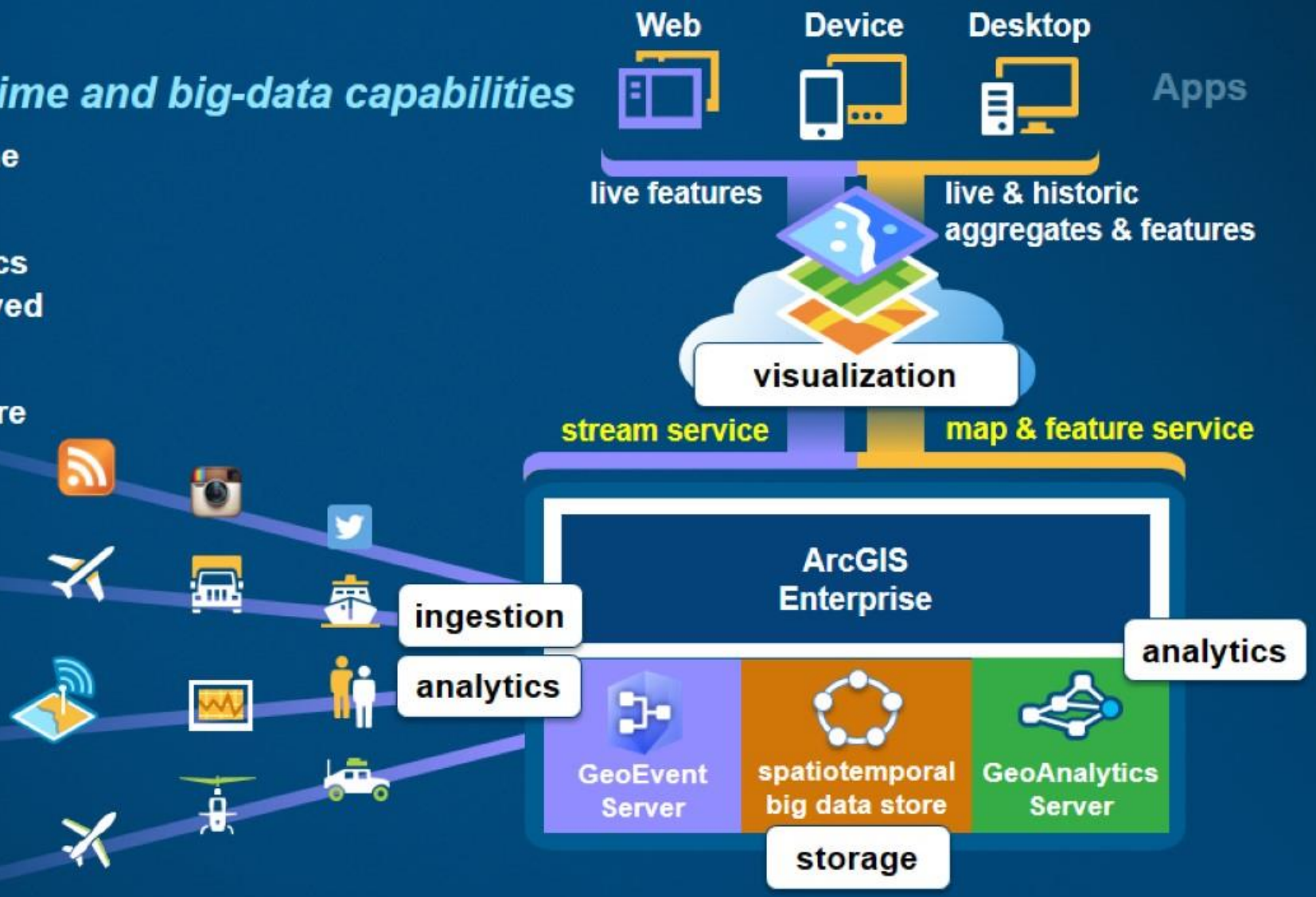
The Internet of Things

Using GeoEvent Server for IoT

ArcGIS Enterprise

GeoEvent Server – Real-time and big-data capabilities

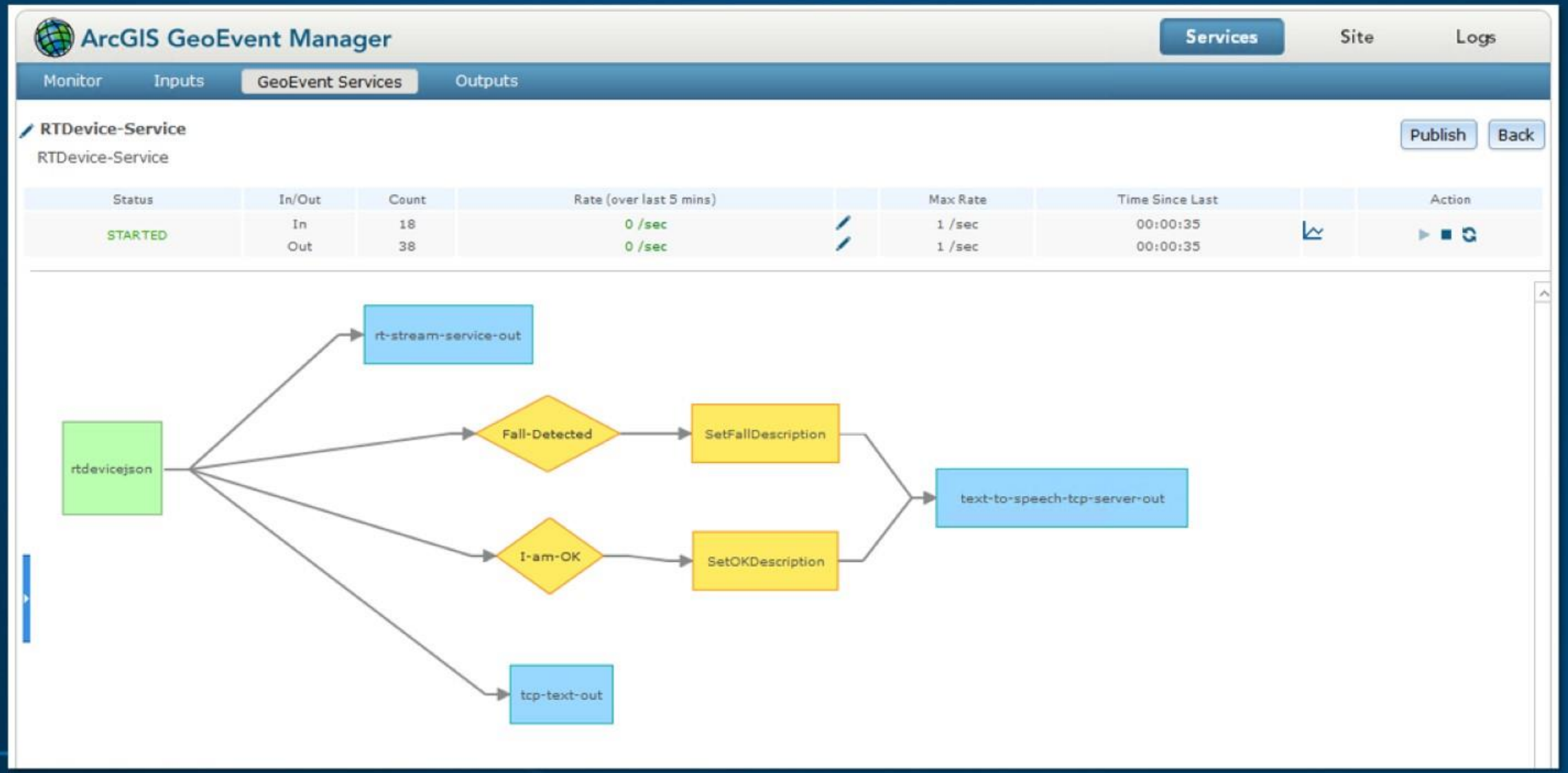
- Ingest high velocity real-time data into ArcGIS
- Perform continuous analytics on events as they are received
- Store observations in a spatiotemporal big data store
- Run batch analytics on stored observations
- Visualize high velocity & volume data:
  - as an aggregation
  - as discrete features
- Notify those who need to know about patterns of interest



GeoEvent Server is a "server role" extending the capabilities of your ArcGIS Enterprise …

Internet of Things (IoT)

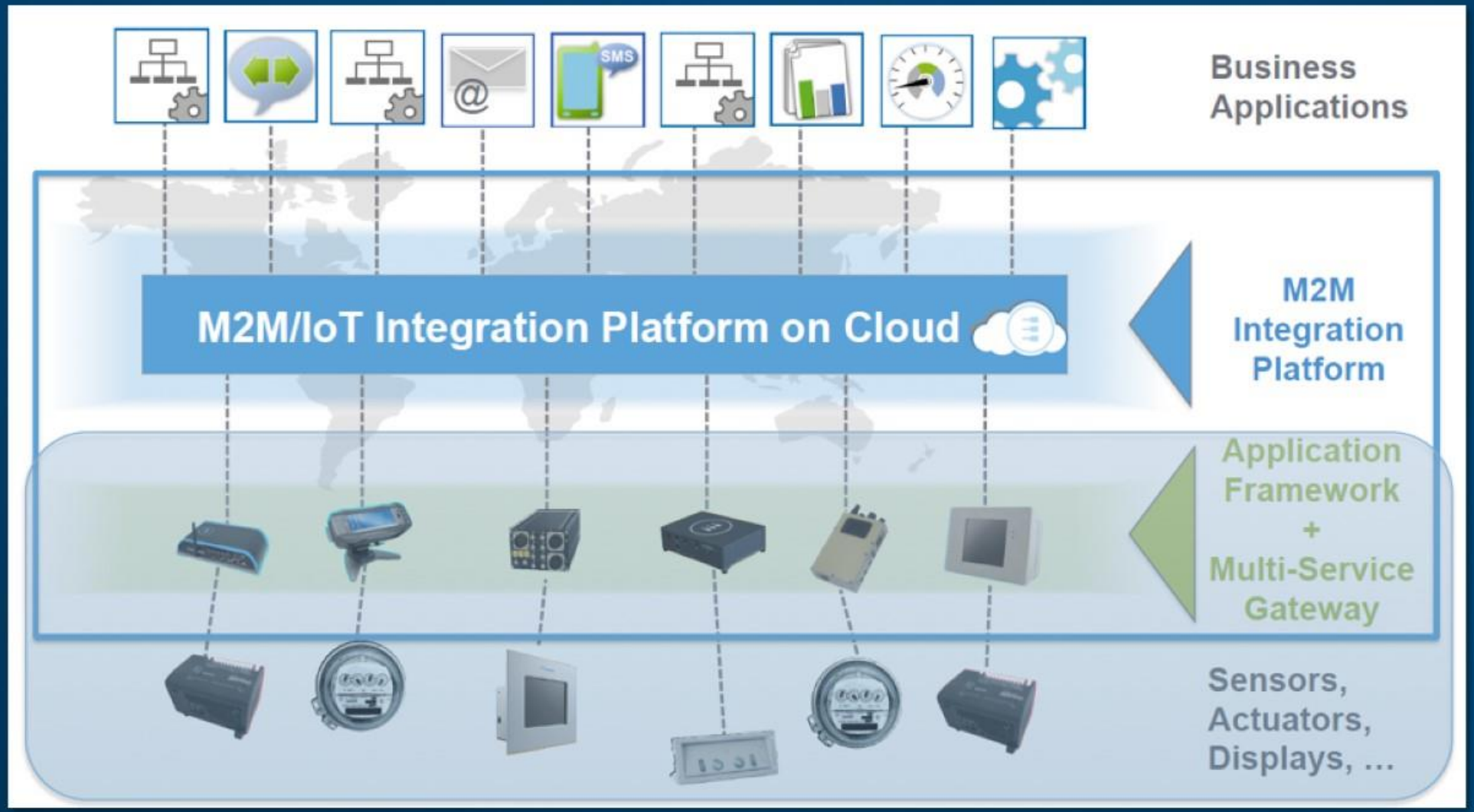
Smartphone Demo



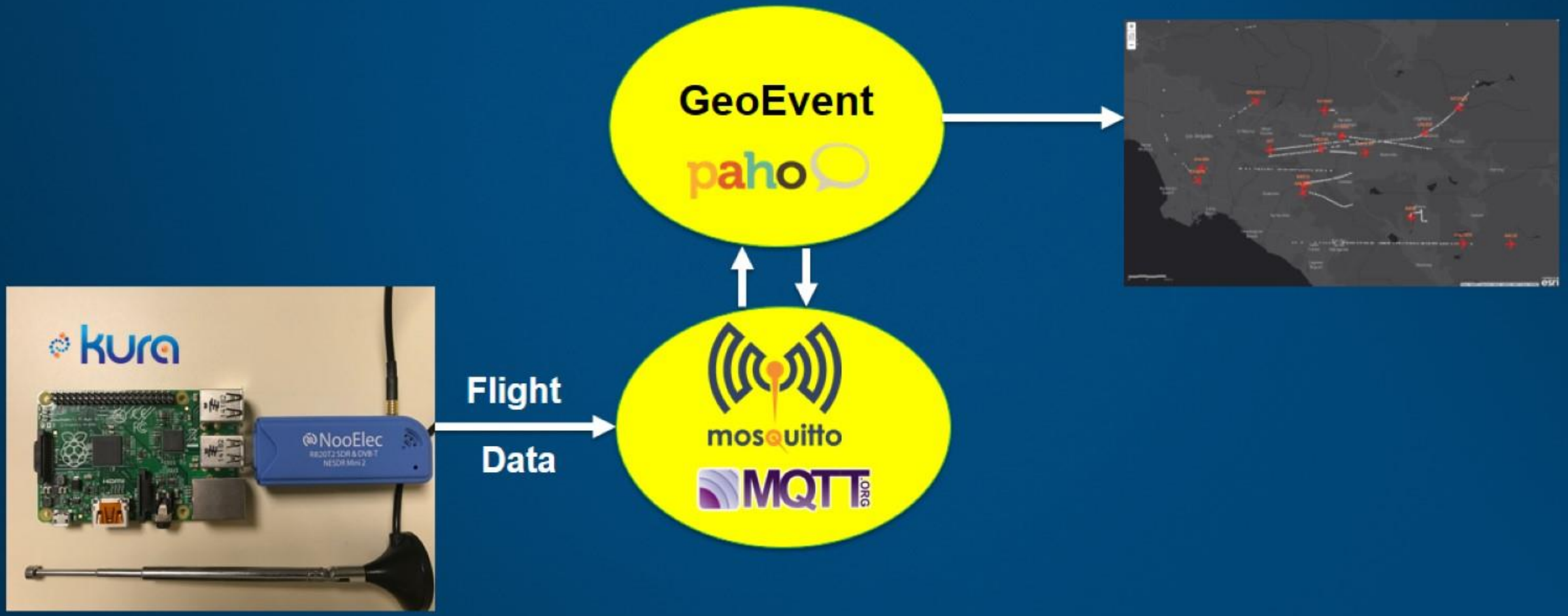
Demo

Raspberry PI as a Flight Sensor

Internet Of Things Architecture



Connecting IoT Devices with GeoEvent



- a machine-to-machine (M2M)/"Internet of Things" connectivity protocol.
- an extremely lightweight publish/subscribe messaging transport.

- a Java/OSGi-based framework for IoT gateways.
- offers access to the underlying hardware (serial ports, GPS, watchdog, GPIOs, I2C, etc.)
- manages network configurations, communication with M2M/IoT Integration Platforms

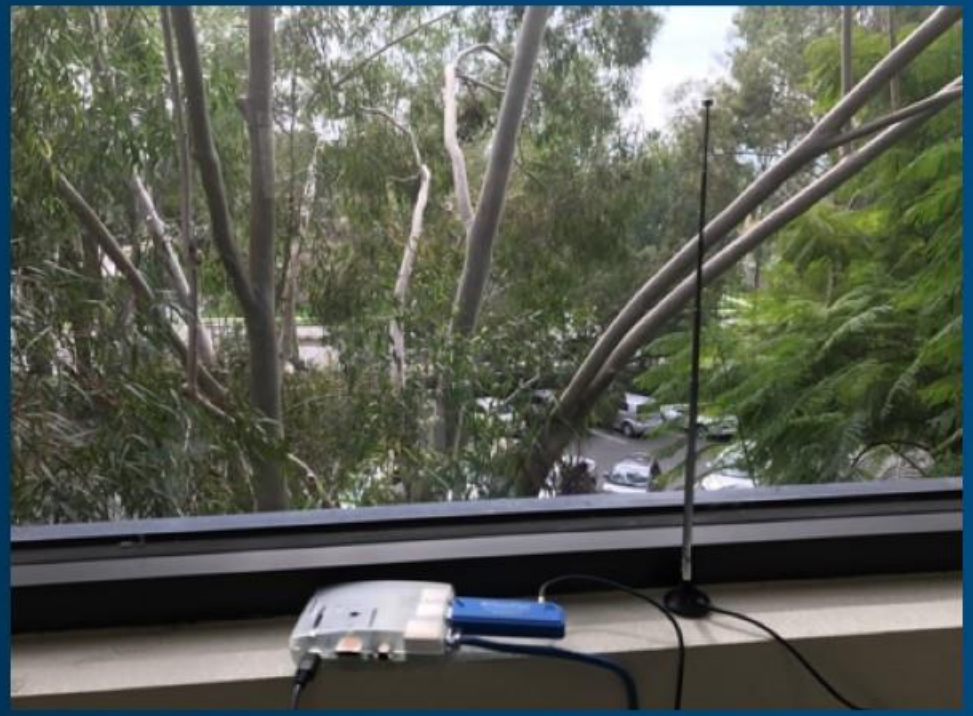
- provides open-source client implementations of open and standard messaging protocols aimed at new, existing, and emerging applications for Machine-to-Machine (M2M) and Internet of Things (IoT).

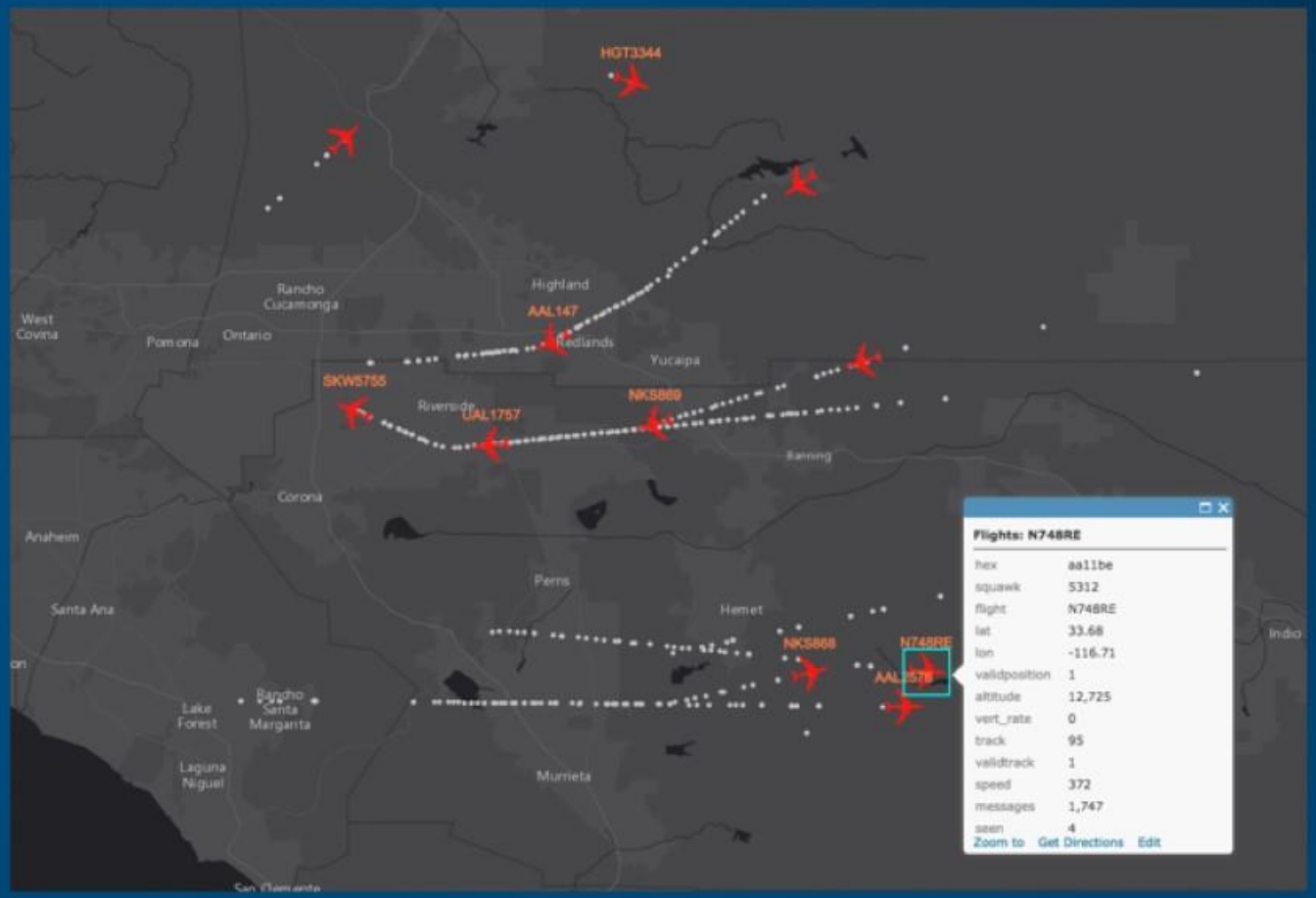
Internet of Things (IoT)

Flight Sensor Demo

Internet of Things (IoT)

Flight Sensor Demo





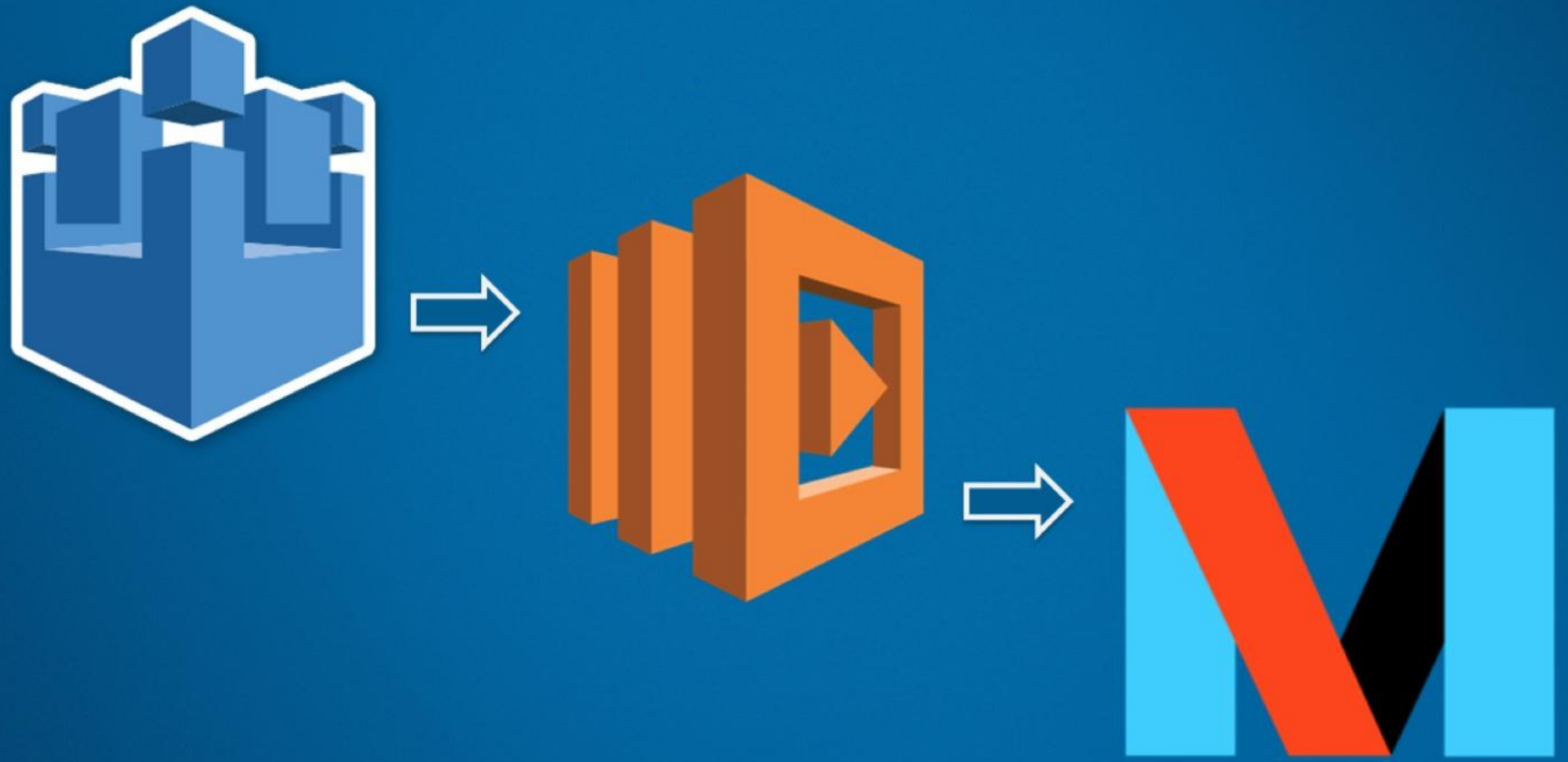
Resources

- **Flight Sensor Demo**

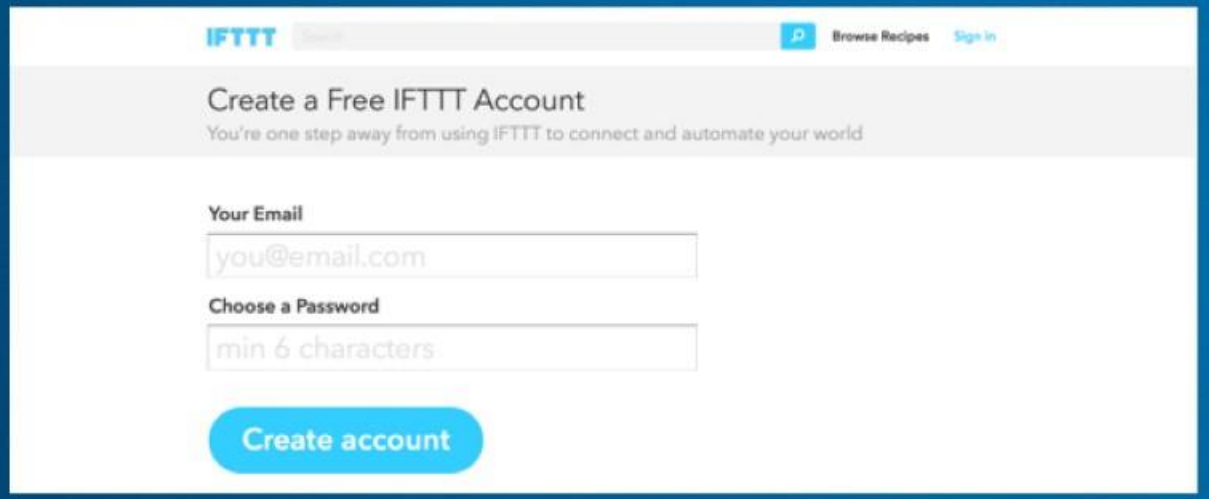
  https://github.com/mzesri/flight-sensor-demo

Demo

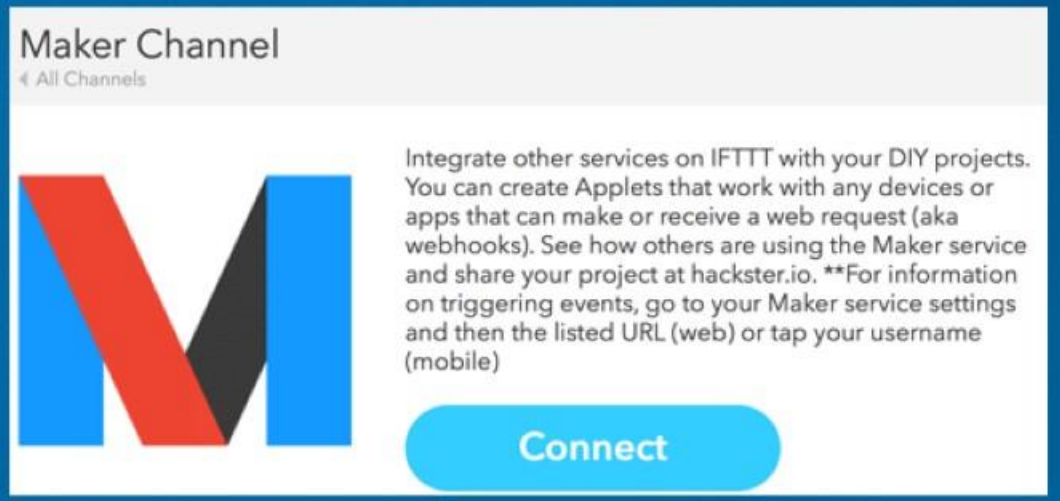
AWS IoT Button



https://aws.amazon.com/start-now/



https://internal-api.ifttt.com/join



https://internal-api.ifttt.com/maker

esri | THE SCIENCE OF WHERE™

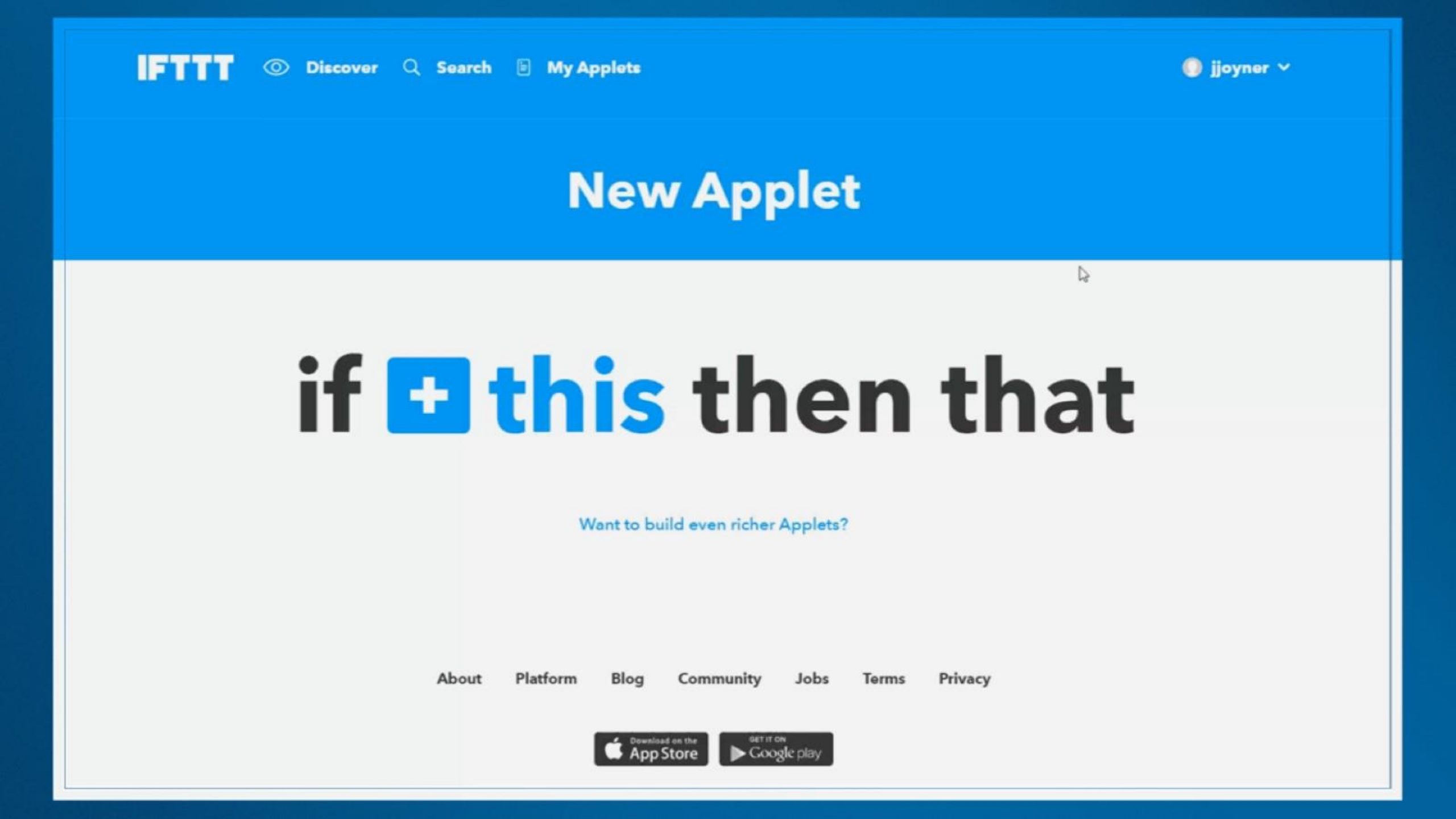
CONFIGURING AWS IoT BUTTON

Services | Resource Groups

```
/**
 * This is a sample that connects Lambda with IFTTT Maker channel. The event is
 * sent in this format: <serialNumber>-<clickType>.
 *
 * The following JSON template shows what is sent as the payload:
{
    "serialNumber": "GXXXXXXXXXXXXXXXX",
    "batteryVoltage": "xxmV",
    "clickType": "SINGLE" | "DOUBLE" | "LONG"
}
 *
 * A "LONG" clickType is sent if the first press lasts longer than 1.5 seconds.
 * "SINGLE" and "DOUBLE" clickType payloads are sent for short clicks.
 *
 * For more documentation, follow the link below.
 * http://docs.aws.amazon.com/iot/latest/developerguide/iot-lambda-rule.html
 */

'use strict';

const https = require('https');

const makerKey = '[redacted]'; // change it to your Maker key

exports.handler = (event, context, callback) => {
    console.log('Received event:', event);

    // make sure you created a receipe for event <serialNumber>-<clickType>
    const makerEvent = `${event.serialNumber}-${event.clickType}`;
    const url = `https://maker.ifttt.com/trigger/${makerEvent}/with/key/${makerKey}`;
    https.get(url, (res) => {
        let body = '';
        console.log(`STATUS: ${res.statusCode}`);
        res.on('data', (chunk) => body += chunk);
        res.on('end', () => {
            console.log('Event has been sent to IFTTT Maker channel');
            callback(null, body);
        });
    }).on('error', (e) => {
        console.log('Failed to trigger Maker channel', e);
        callback(`Failed to trigger Maker channel: ${e.message}`);
    });
};
```

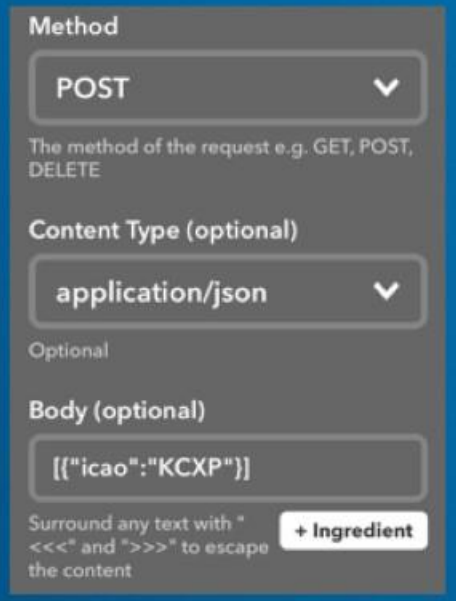
```
 * The following JSON template shows what is sent as the payload:
{
    "serialNumber": "GXXXXXXXXXXXXXXXX",
    "batteryVoltage": "xxmV",
    "clickType": "SINGLE" | "DOUBLE" | "LONG"
}
 *
 * A "LONG" clickType is sent if the first press lasts longer than 1.5 seconds.
 * "SINGLE" and "DOUBLE" clickType payloads are sent for short clicks.
```

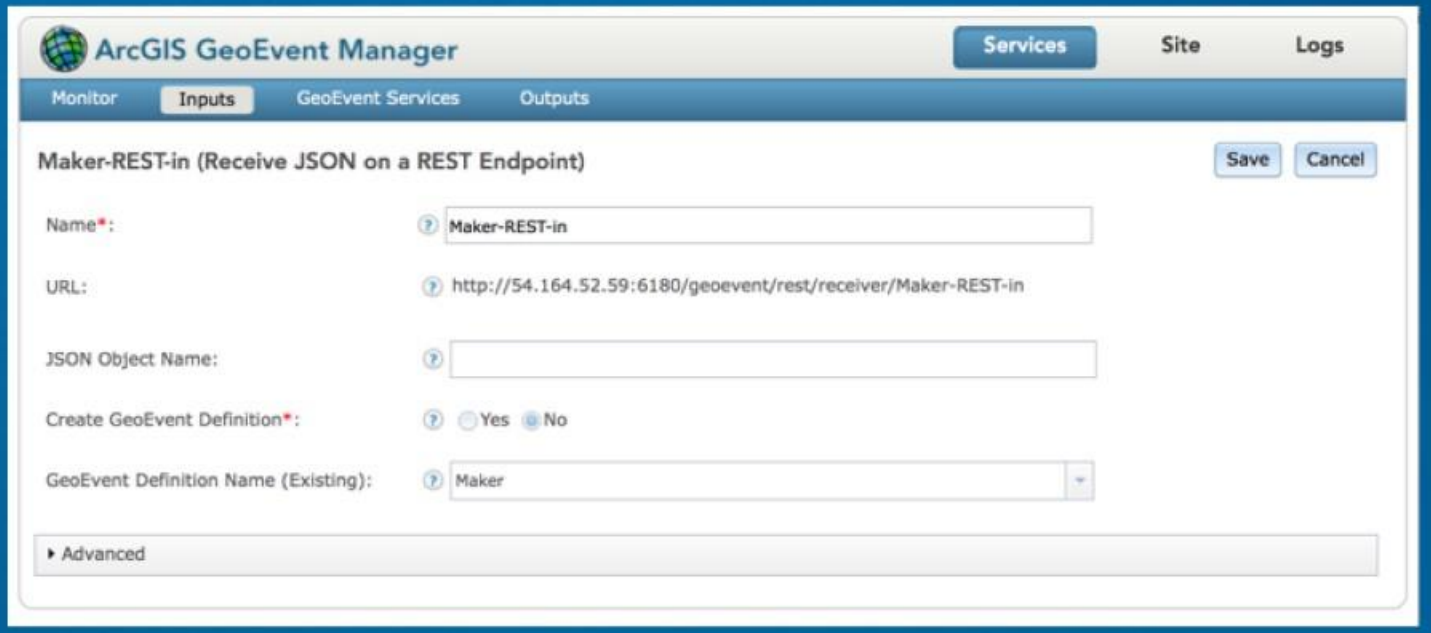
```
const makerKey = '[redacted]'; // change it to your Maker key

exports.handler = (event, context, callback) => {
    console.log('Received event:', event);

    // make sure you created a receipe for event <serialNumber>-<clickType>
    const makerEvent = `${event.serialNumber}-${event.clickType}`;
    const url = `https://maker.ifttt.com/trigger/${makerEvent}/with/key/${makerKey}`;
```


IFTTT
Discover
Search
My Applets
jjoyner
New Applet
if this then that
Want to build even richer Applets?
About
Platform
Blog
Community
Jobs
Terms
Privacy
Download on the App Store
GET IT ON Google play


If Maker Event "LONG", then make a web request
On
If Maker Event "DOUBLE", then call my phone at 7049296024 (update phone number)
On
works with
If Maker Event "SINGLE", then send me an SMS at 7049296024 (update phone number)
On
works with


Make a web request
This action will make a web request to a publicly accessible URL. NOTE: Requests may be rate limited.
URL
http://54.164.52.59:6180/geoevent/rest/receiver/Maker-REST-in
Surround any text with "<<<" and ">>>" to escape the content
+ Ingredient


Method
POST
The method of the request e.g. GET, POST, DELETE
Content Type (optional)
application/json
Optional
Body (optional)
[{"icao":"KCXP"}]
Surround any text with "<<<" and ">>>" to escape the content
+ Ingredient


ArcGIS GeoEvent Manager
Services
Site
Logs
Monitor
Inputs
GeoEvent Services
Outputs
Maker-REST-in (Receive JSON on a REST Endpoint)
Save
Cancel
Name*:
Maker-REST-in
URL:
http://54.164.52.59:6180/geoevent/rest/receiver/Maker-REST-in
JSON Object Name:
Create GeoEvent Definition*:
Yes
No
GeoEvent Definition Name (Existing):
Maker
Advanced

Maker Enrichment to Speech *

Publish Back

Status	In/Out	Count	Rate (over last 5 mins)	Edit Rate	Max Rate	Time Since Last	View Graph	Action
STARTED	In	0	0 /sec		0 /sec	00:07:43		
	Out	0	0 /sec		0 /sec	00:07:43		

Layout

New Elements

Filter

Processor

Inputs

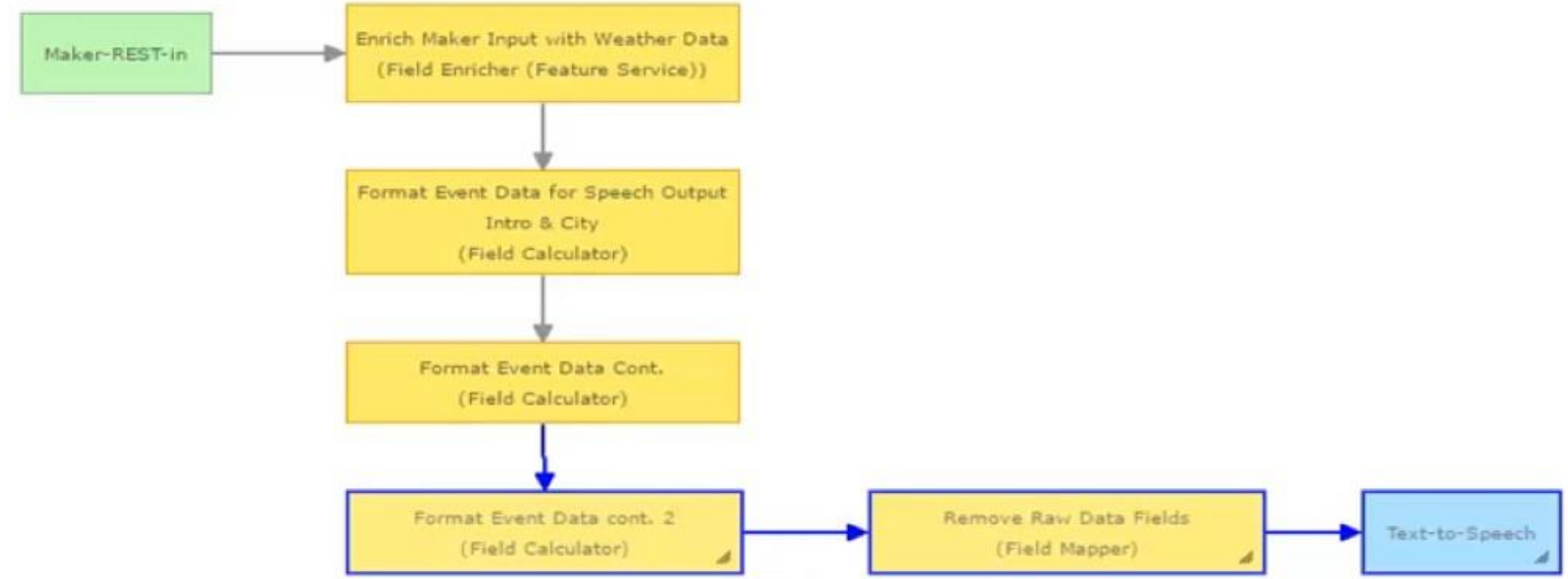
Maker-REST-in

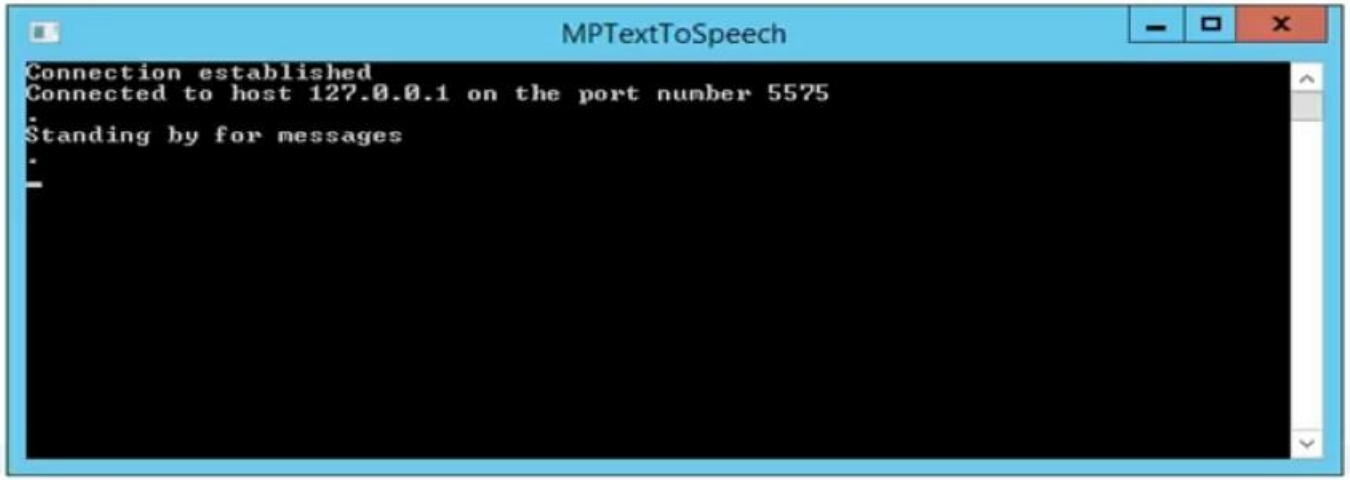
METAR-fs-poll-in

Outputs

METAR-fs-out

Text-to-Speech





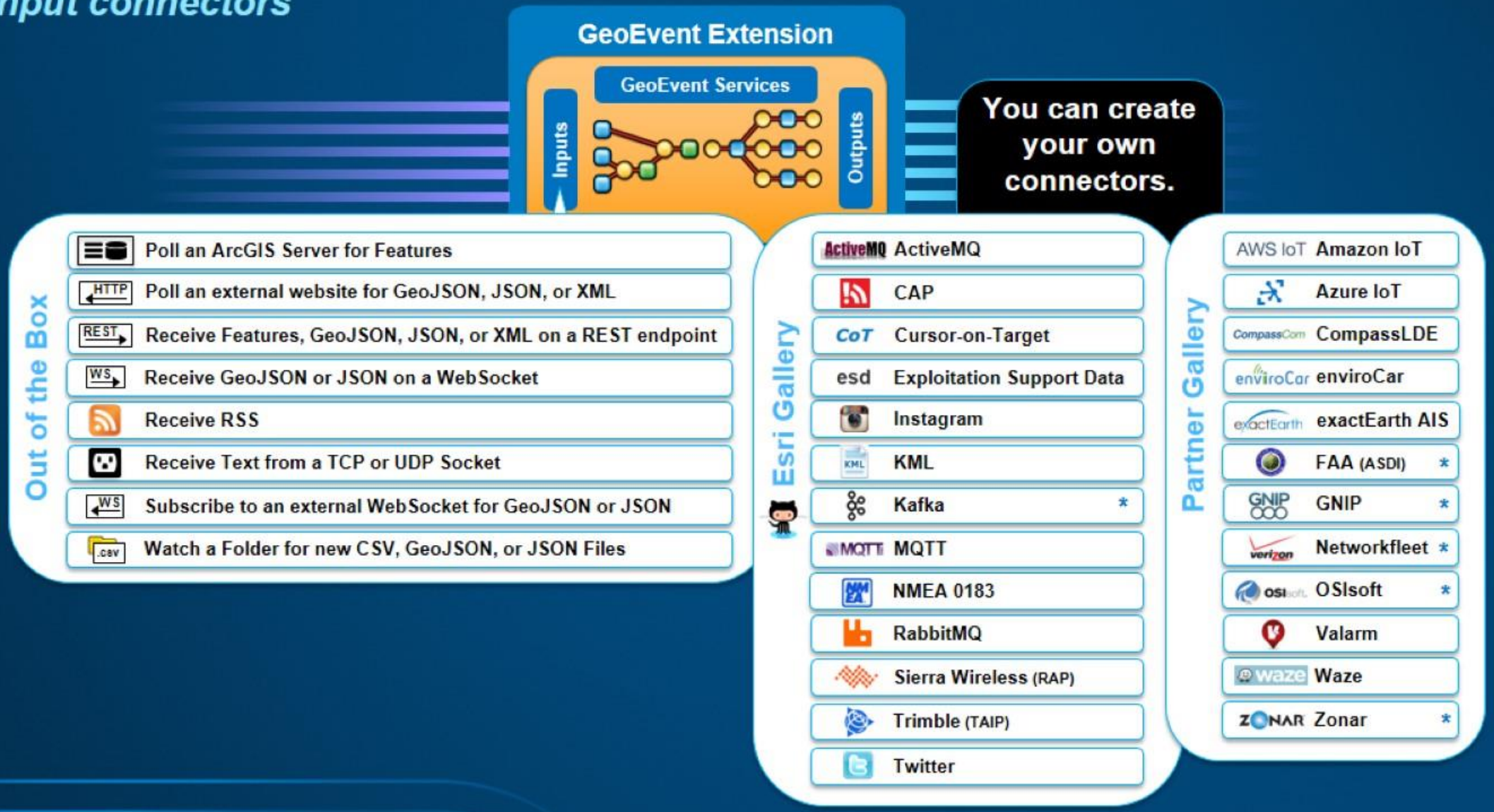
The Internet of Things

Collecting and Storing IoT Data

ARM: *"big data" analysis, used to create intelligence, begins with "little data"*

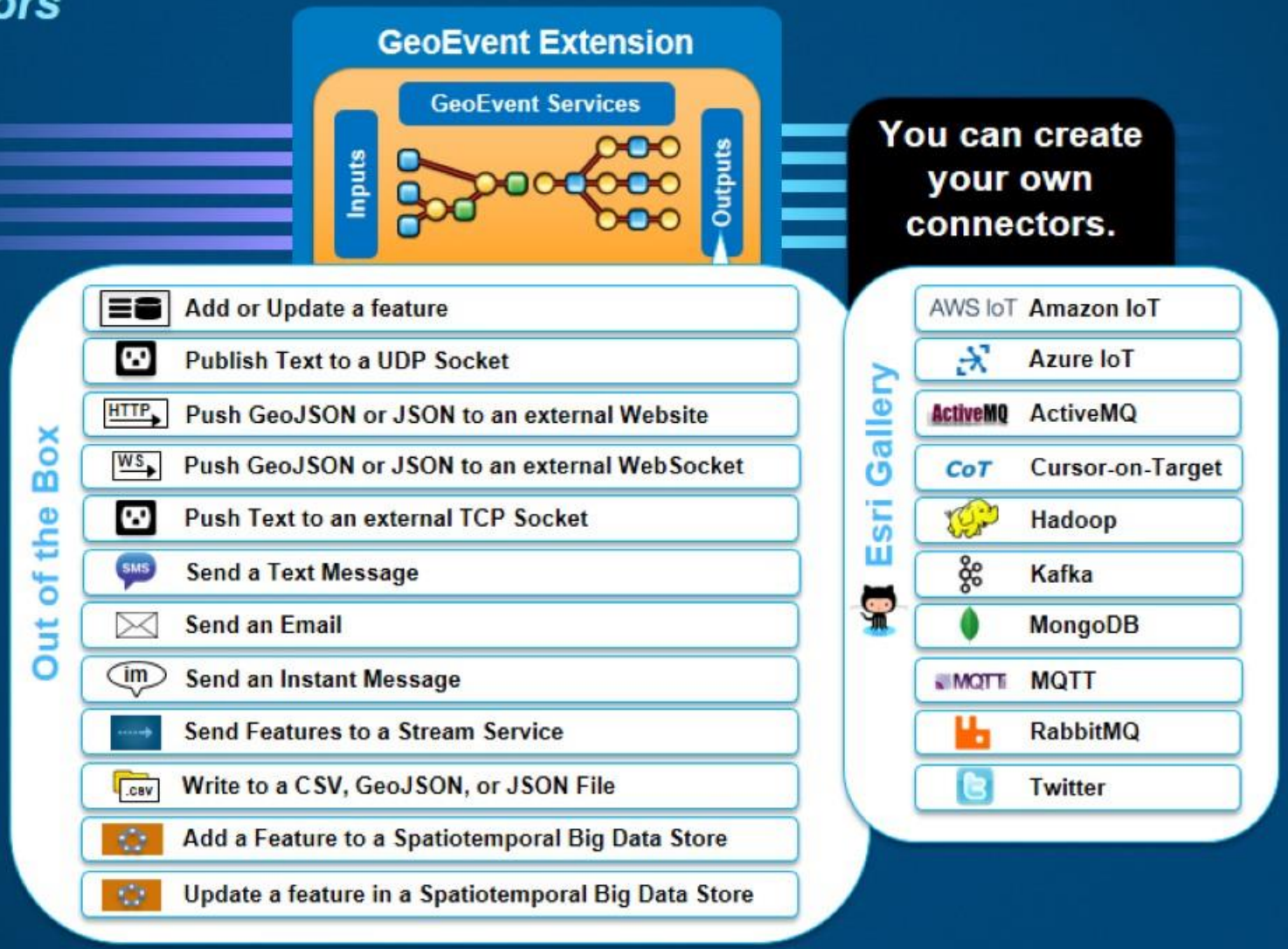
Ingesting real-time data into ArcGIS

Input connectors



Storing real-time data in ArcGIS and alerting

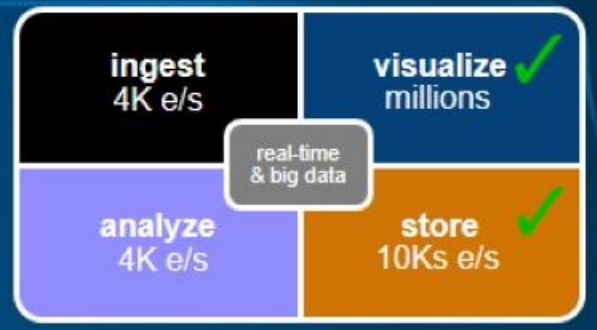
Output connectors

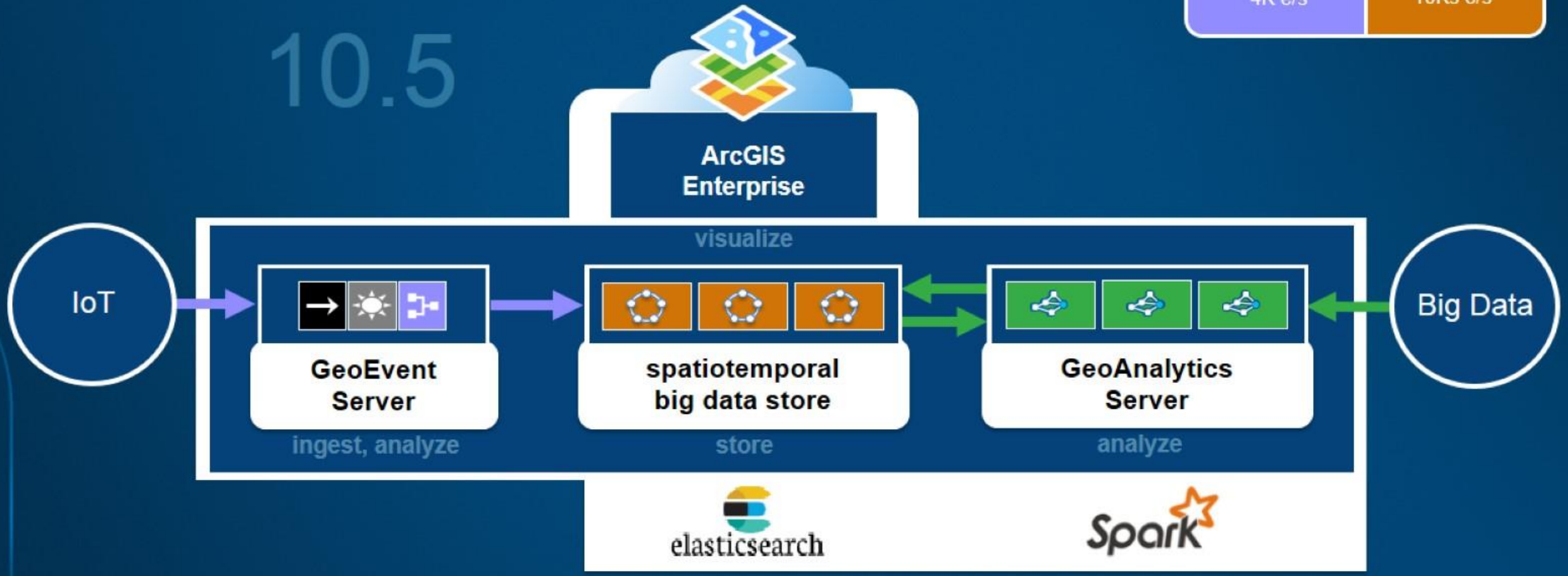


ArcGIS Enterprise

with real-time & big data capabilities

10.5



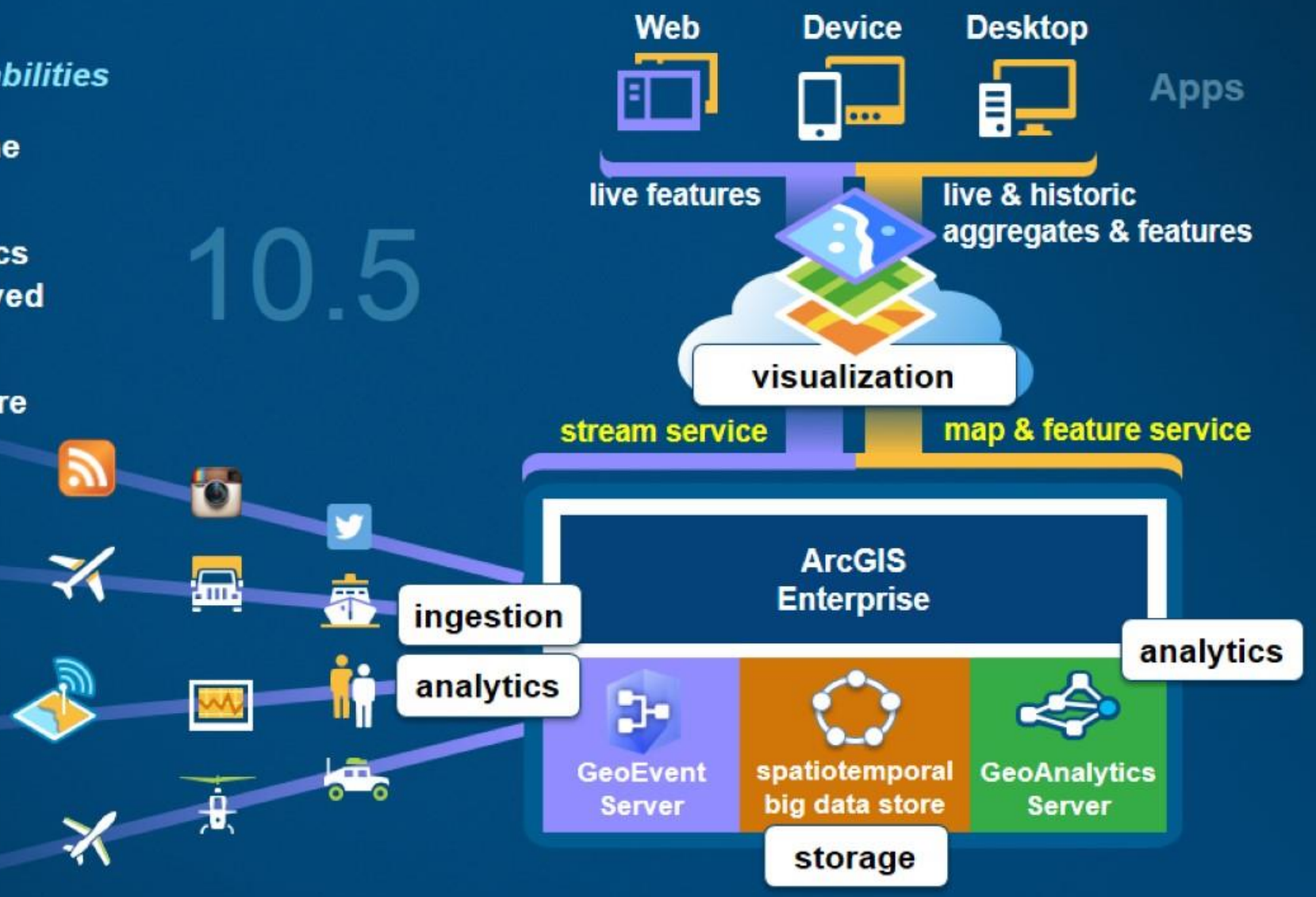


ArcGIS Enterprise

with real-time & big data capabilities

- Ingest high velocity real-time data into ArcGIS
- Perform continuous analytics on events as they are received
- Store observations in a spatiotemporal big data store
- Run batch analytics on stored observations
- Visualize high velocity & volume data:
  - as an aggregation
  - as discrete features
- Notify those who need to know about patterns of interest

10.5



ArcGIS GeoSpatial IoT

Handling GeoSpatial aspects of IoT at the Massive Scale

Real-Time GIS

bringing geospatial insights to your IoT

Environment

noise co2 nitrates
gases temperature humidity
atmospheric pressure radiation
pesticides electromagnetic feedback
rain gauges water level gauges
water quality air quality

Weather

warnings earthquakes
precipitation icy conditions

Airports

flight status queues
plane location runway status

Public Safety

police fire
surveillance

Connected Cars

autonomous driving traffic conditions holes
parking meters road conditions slippery areas
network improvements

Buildings

lighting hvac
occupancy counts

Web Device Desktop

ArcGIS Enterprise

with real-time & big data capabilities

ingest, store, analyze, visualize

Transit

buses taxis rail
trains crowds

Energy Usage

electricity gas smart meters

City Workers

sanitation snow plows

People

health monitoring
social activity

Public Health

hospitals ambulances

Telecommunications

cell phone signals dropped calls

Trinity
as a Managed Service
bringing geospatial insights to your IoT

Web Device Desktop Apps

Task Type:	**Real-Time Analytic**
Task Name:	**rat1**
Instances:	**20**
Cores:	4
Memory:	8GB
Disk Space:	100GB
Constraints:	role != storage

on Amazon C2S

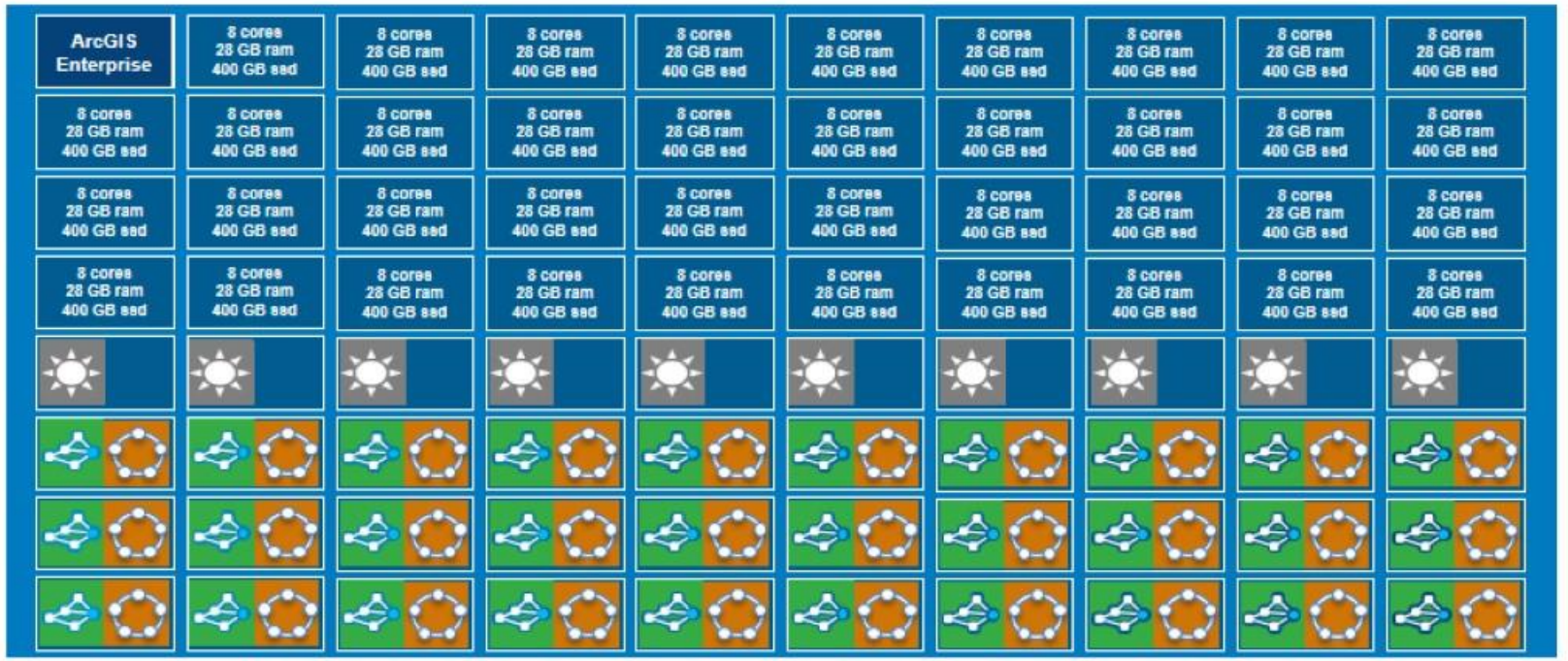
on Amazon

on Azure

Managed Service

ArcGIS Enterprise with real-time & big data
880 cores, 3TB ram, 50TB ssd, 80 nodes

DC/OS



sources Scala | hubs kafka | real-time analytics Spark | spatiotemporal archive elasticsearch | batch analytics Spark

Trinity
as a Managed Service
bringing geospatial insights to your IoT

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DC/OS

sources Scala | hubs kafka | real-time analytics Spark | spatiotemporal archive elasticsearch | batch analytics Spark

Summary

The Internet of Things

- **Internet of Things is fast growing:**
  - More devices and sensors
  - New connection protocols and data formats
  - New applications
- **New challenges:**
  - Scalability, load balancing, high availability, analytics, storage, security, visualization
  - Low latency, locality to things
- **Real-Time GIS is evolving:**
  - Faster ingestion
  - Handling of bursty data/back pressure
  - Fast and efficient real-time analytics and presentations
  - Handling of rapid and high volume storage – historical data

Real-Time & Big Data GIS

other sessions

• **GeoEvent Server: Internet of Things (IoT)**	Tue, 1:00-2:00pm, Primrose B Fri, 1:00-2:00pm, Primrose
• **GeoEvent Server: Introduction**	Tue, 5:30pm-6:30pm, Primrose B
• **Visualizing Big Data with ArcGIS API for JavaScript & WebGL**	Tue, 2:30-3:30pm, Primrose B
• **GeoEvent Server: Creating Connectors using GeoEvent SDK**	Wed, 2:30-3:30pm, Santa Rosa
• **GeoEvent Server: Creating Processors using GeoEvent SDK**	Wed, 4:00-5:00pm, Santa Rosa
• **Real-Time & Big Data GIS at a Massive Scale**	Wed, 4:00-5:00pm, Smoketree A-E
• **Big Data & ArcGIS: Introduction to GeoAnalytics Server**	Thu, 10:30-11:30am, Mojave Learning Center
• **GeoEvent Server: Applying Real-Time Analytics**	Thu, 10:30-11:30am, Primrose B
• **GeoEvent Server: Best Practices**	Thu, 2:15-3:15pm, Primrose C-D
• **Developing Real-Time Web Apps with JavaScript**	Thu, 3:00-3:30pm, Demo Theater 1, Oasis 1
• **Big Data: Leveraging the Spatiotemporal Big Data Store**	Thu, 4:00-5:00pm, Catalina/Madera
• **Building Android Location Awareness with GeoEvent Server**	Thu, 6:00-6:30pm, Mesquite C
• **GeoEvent Server: Making 3D Scenes Come Alive**	Fri, 8:30-9:30am, Primrose C-D

Please Take Our Survey!

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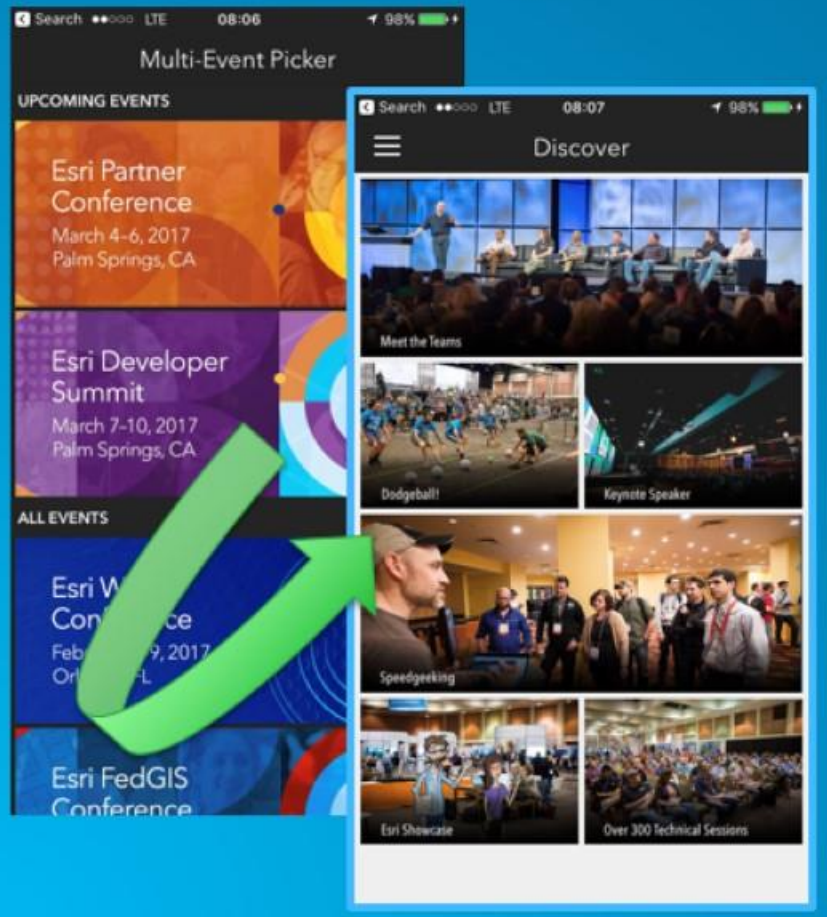
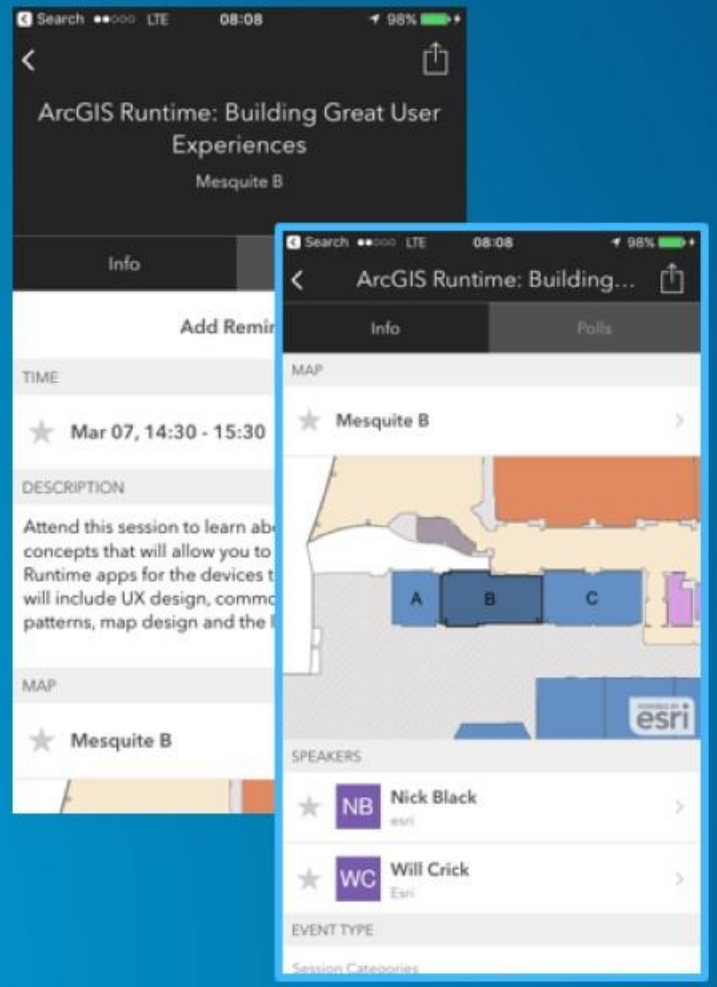


Select the session you attended



Scroll down to the "Feedback" section

Complete Answers, add a Comment, and Select "Submit"

Questions / Feedback?

To learn more:
http://links.esri.com/geoevent
http://links.esri.com/geoevent-forum

esri | THE SCIENCE OF WHERE™

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